[Established 1832]
THE OLDEST RAILROAD JOURNAL IN THE WORLD

# AMERICAN ENGINEER AND RAILROAD JOURNAL.

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R. M. VAN ARSDALE, INC.
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J. S. BONSALL, Vice-President and General Manager

F. H. THOMPSON, Advertising Manager.

Editors:
E. A. AVERILL. OSCAR KUENZEL.

JUNE, 1910

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This condition is a serious reflection upon American motive power departments and is one which it is to be hoped will very shortly be overcome. As a matter of fact the time has now arrived when we must use the largest locomotives and we must have increased complication to give greater economy, and we must take care of this power and keep it in first-class condition. The Mallet articulated compound locomotive equipped with feed water heaters, superheaters, reheaters and other complications, has arrived, is going to stay and the railroads cannot escape it. They must provide themselves with men and facilities to take care of this power as it is. Possibly it has arrived a little ahead of its time, but the fact remains that it has arrived, and the motive

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power departments of this country are about to undergo a test of efficiency and ability such as they have never been brought into contact with before.

## RULES OF INTERCHANGE.

The rules of interchange probably represent the most valuable result of the formation of the Master Car Builders' Association. The value of these rules, however, is dependent very largely upon their universal acceptance and use by all members and it behooves the association as a whole to protect its own work by actively discouraging any violation or disregard of its rules. There has developed, during the past few years, a certain tendency among small local associations of railroad officers, joint car inspectors, etc., to disregard the M. C. B. rules of interchange and formulate their own code to suit "local conditions." Actions of this kind cannot be too strongly condemned. While it is quite possible that the rules of interchange in their present form are not the best that can be drawn up, the proper course is to have these rules revised rather than for each local point to use its own judgment as to whether they will be governed by them or not. The association has full power to change the rules and they can be altered so as to properly cover the conditions at practically every important point. It is, of course, true that conditions at all points are not the same and that the rules may not be flexible enough to do justice in all cases, but the remedy is not for the subscriber to calmly disregard the rules and make others to suit himself. It is easy to imagine the confusion that will surely result if each interchange point is to be governed by a different set of rules. As a matter of fact the result cannot help but be the practical paralyzation of through routing of freight.

The M. C. B. Association was formed primarily for the purpose of expediting the movement of freight cars between railroads and while its other activities, such as placing of responsibility of defects and the adoption of standards, are of great importance, they are secondary to this and it devolves upon the association to do all in its power to uphold its rules of interchange if it is to continue to hold the important place in the field of transportation that it now occupies.

This subject is of unusual importance just at this time when there is so much agitation in connection with the government regulation of railways. If railroads cannot obey their own rules what argument have they to advance against regulation by the government? It is only bodies that are capable of governing themselves that have a right to self-government and the railroad companies of this country cannot at the present time allow the impression to go forth that they are not able to formulate rules for interchange or otherwise, which are enforcible and will be obeyed.

We have reason to believe that this subject will be brought before the convention of the Master Car Builders' Association this year and trust that it will be given the attention its importance deserves and that some means will be found of satisfactorily solving the difficulty.

# FRONT END TESTS

## RESULTS OF A SERIES OF TESTS ON THE LOCOMOTIVE TESTING PLANT AT ALTOONA TO DETERMINE THE BEST ARRANGEMENT OF FRONT ENDS FOR PENNSYLVANIA ATLANTIC TYPE LOCOMOTIVES, CLASSES E2a AND E3a.

(EDITOR'S NOTE.—*Below is given a general summary of the results of the tests made on locomotive front ends on the Pennsylvania Railroad testing plant at Altoona. In the following issue will be given a complete account of the various tests which led to these final conclusions.*)

A large number of tests of various kinds have been made on the testing plant with class E2a locomotive, No. 5266, which was equipped with a standard front end (Fig. 1) and while this was found to be a very good arrangement, so far as the steaming of the locomotive was concerned, it was not self-clearing and with some of the friable coals used the accumulation of cinders in the front end sometimes amounted to as much as 1,000 lbs. per hour. With gas coals the accumulation was not quite so serious, but often with these, 300 lbs. or more might be collected in an hour.

It was decided to experiment with various arrangements of front end apparatus to determine if it was possible to obtain one which would be equally successful with the standard for good steaming qualities, but which would also be self clearing. A number of tests were made on the testing plant with various arrangements, some of which showed themselves to be unsuccessful after a short time, and others proved successful in some respects, but unsuccessful in others.

After a number of preliminary runs of this kind it was found that three arrangements gave much better results than any of the others, and final tests were made to determine the relative value of these.

In estimating the comparative merits of the different devices tried, the following features were taken into consideration:

The quantity of water that could be evaporated as compared with the standard front end.

The evaporation per lb. of coal.

The general steaming of the locomotive.

The amount of cinders collected in the smoke box or discharged from the stack.

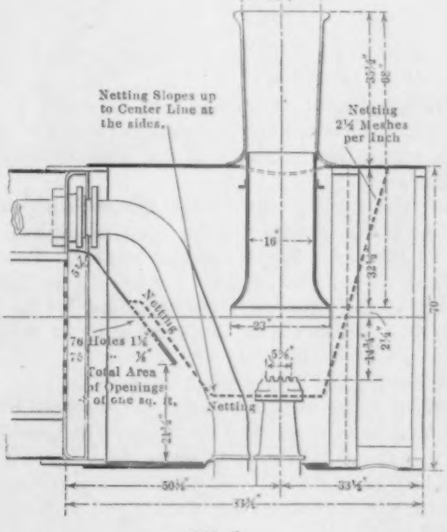


FIG. I.

The tests made with these three arrangements were each of two hours' duration at 160 r. p. m., or 38 miles per hour. Good results were obtained with each arrangement (Figs. 2, 3 and 4), they all being perfectly self clearing except for a slight accumulation of cinders on the horizontal plate of the diaphragm.

**In the following table some of the results of the tests with the standard (Fig. 1) front end and the arrangements shown in Figs. 2, 3 and 5, are given, these showing the results with two qualities of coal, the gas coal being the one normally used for passenger service.**

| R. P. M. | Cut-off Ins. | Throttle. | Duration of test. Hours. | Speed in miles per hour. | Front end arrangement. Figure number. | Cinders collected in smoke-box. Pounds per hour. | Sparks discharged from stack. Pounds per hour. | Boiler pressure. Pounds per square inch. | Evaporation, Dry Steam per sq. ft. of heating surface. Lbs. per hour. | Equivalent evaporation per sq. foot of heating surface. Pounds per hour. | Equivalent evaporation per pound of dry coal. | Coal fired. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 27 | Full | 3 | 38 | 1 | 492 | 140 | 188.4 | 12.24 | 15.0 | 7.25 | Friable |
| 160 | 27 | Full | 1 | 38 | 2 | 10 | 529 | 199.9 | 12.25 | 14.76 | 7.28 | " |
| 160 | 27 | Full | 1 | 38 | 2 | 10 | 485 | 198.6 | 12.09 | 14.54 | 7.87 | " |
| 160 | 32 | Full | 2 | 38 | 1 | 326 | 341 | 201.2 | 15.04 | 18.24 | 7.01 | Gas |
| 160 | 32 | Full | 1 | 38 | 2 | 6 | 516 | 204.1 | 15.08 | 18.17 | 7.39 | " |
| 160 | 3 | Full | 2 | 38 | 3 | 0 | 303 | 199.5 | 14.80 | 17.89 | 8.65 | " |
| 200 | 25 | Full | 1 | 46 | 3 | 0 | 467 | 199.6 | 14.55 | 17.73 | 7.33 | " |
| 200 | 25 | Full | 1 | 46 | 4 | 0 | 293 | 202.7 | 14.38 | 17.63 | 8.15 | " |

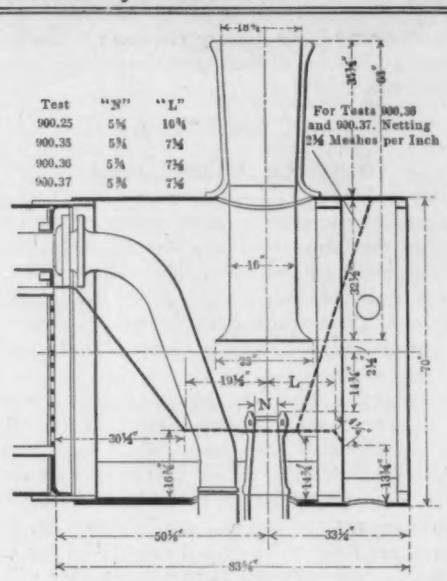


FIG. 2.

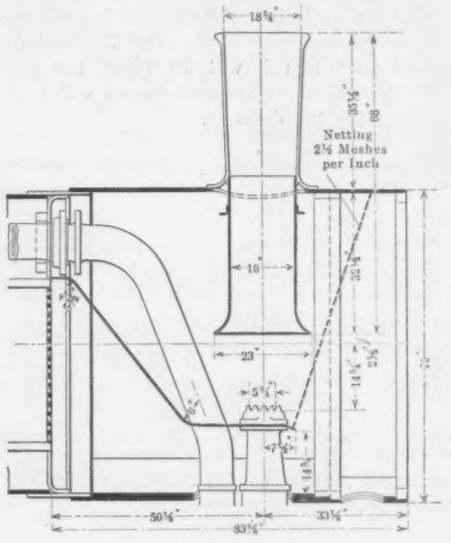


FIG. 3.

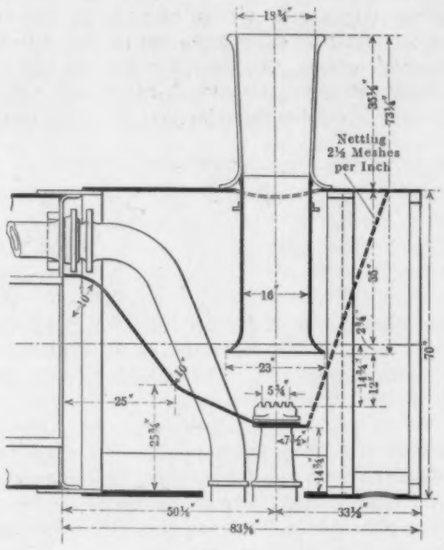


FIG. 4.

The conclusions drawn by the test department from all of the various tests are as follows:

1. A front end arrangement has been developed for the "E" class, which, while self-cleaning, maintains the boiler capacity or maximum evaporation fully equal to that with the standard front end arrangement.

2. With friable coals where large quantities of cinders are formed, the boiler capacity will be increased on long runs, on account of the smoke-box being kept clear of cinders which would obstruct the draft.

3. The front end arrangement recommended for the "E" class of locomotives is that shown in Figure 4, to be used with an exhaust nozzle of 5¾ in. diameter.

4. The outside and inside stacks as now used on this class of locomotive appear to give better results than can be obtained with the form recommended by the Master Mechanics' Committee, and it is thought advisable to retain them.

5. The best results were obtained when the passage for the gases under the diaphragm was smooth and free from abrupt changes of form.

6. The inclined adjustable diaphragm plate, often used, was found to cause an obstruction to the flow of gases and is undesirable. In the experiments made, the height of the whole horizontal plate of the diaphragm was varied and the final position recommended is suitable for any locomotive of this class and any means for adjustments is not considered necessary.

WASHING OUT WITH HOT WATER.—The National hot-water locomotive boiler washing and filling system was installed and placed in operation at the Bellefontaine roundhouse in December, 1909. It is equipped with two Dean duplex pumps 12 x 8½ x 12 in.; the capacity of the filling pump is 500 gallons per minute; the washout pump will wash three boilers at a time with a pressure of 90 lbs. The filling storage tank has a capacity of 12,000 gallons, and the washout tank a capacity of 85,000 gallons.

It takes 1 hour 56 minutes to wash and fill a boiler, including the cooling of the boiler and letting out of the water. You can wash a boiler quicker than this, but I doubt if you can do it right. The water in the washout tank is ordinarily about 185 deg. Fahr., being regulated by a valve on the cold water line. This valve is actuated by a thermostat inserted in the tee in the suction line, the thermostat assuring a positive temperature of the washout water. The filling water is ordinarily about 190 to 200 degrees Fahr.

This plant saves water, saves fuel, removes the mud and scale in the boiler before it gets baked, and saves leaky flues.—*C. H. Voges at the General Foremen's Convention.*

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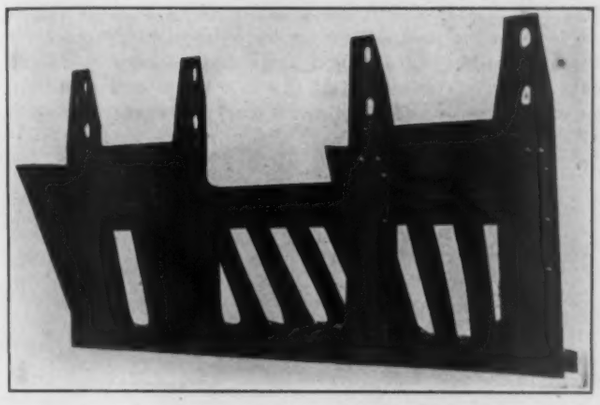
OUTPUT OF NEW SHOPS.—The output of the new shops of the Frisco at Springfield, Mo., for April was 42 locomotives and 46 passenger cars. Seven locomotives were given new fireboxes. The shop worked 25 days during the month with no overtime and had an average of 720 men in the locomotive department.

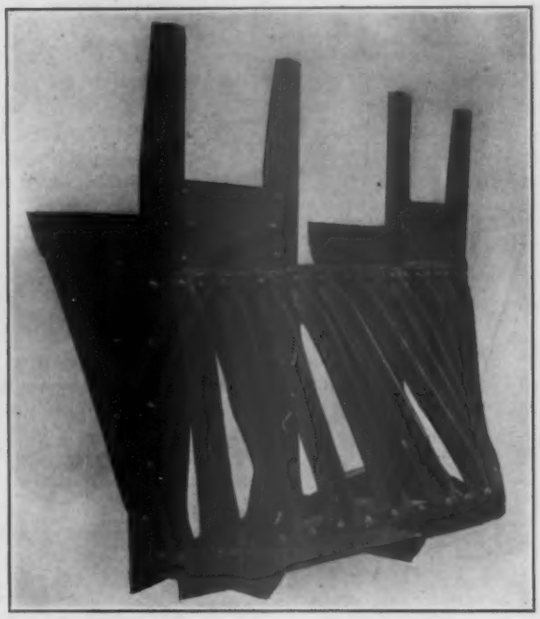
## STEEL LOCOMOTIVE PILOT.

It is the experience of most roads in the maintenance of locomotive pilots that a large percentage of the breakages are due to the pilots striking something, especially coming in contact with each other at the coal docks and ash pits. This difficulty can be eliminated with the wooden pilot by shortening it up, but it is rather a difficult matter to design a shorter wooden pilot of sufficient strength, and to eliminate the trouble steel pilots are usually employed, being in quite general use on many roads.

On the Lake Shore & Michigan Southern Railroad a new design of steel pilot has recently been put into service, which has many features of advantage over the usual arrangement of steel bars and angles. This design is made up almost entirely of pressed steel parts which are formed to give a maximum strength and stiffness with minimum weight. One of these pilots for a freight engine weighs but 340 lbs. as compared with 830 for the wooden pilot which it displaced. It is also found that the steel pilot is much cheaper to construct.

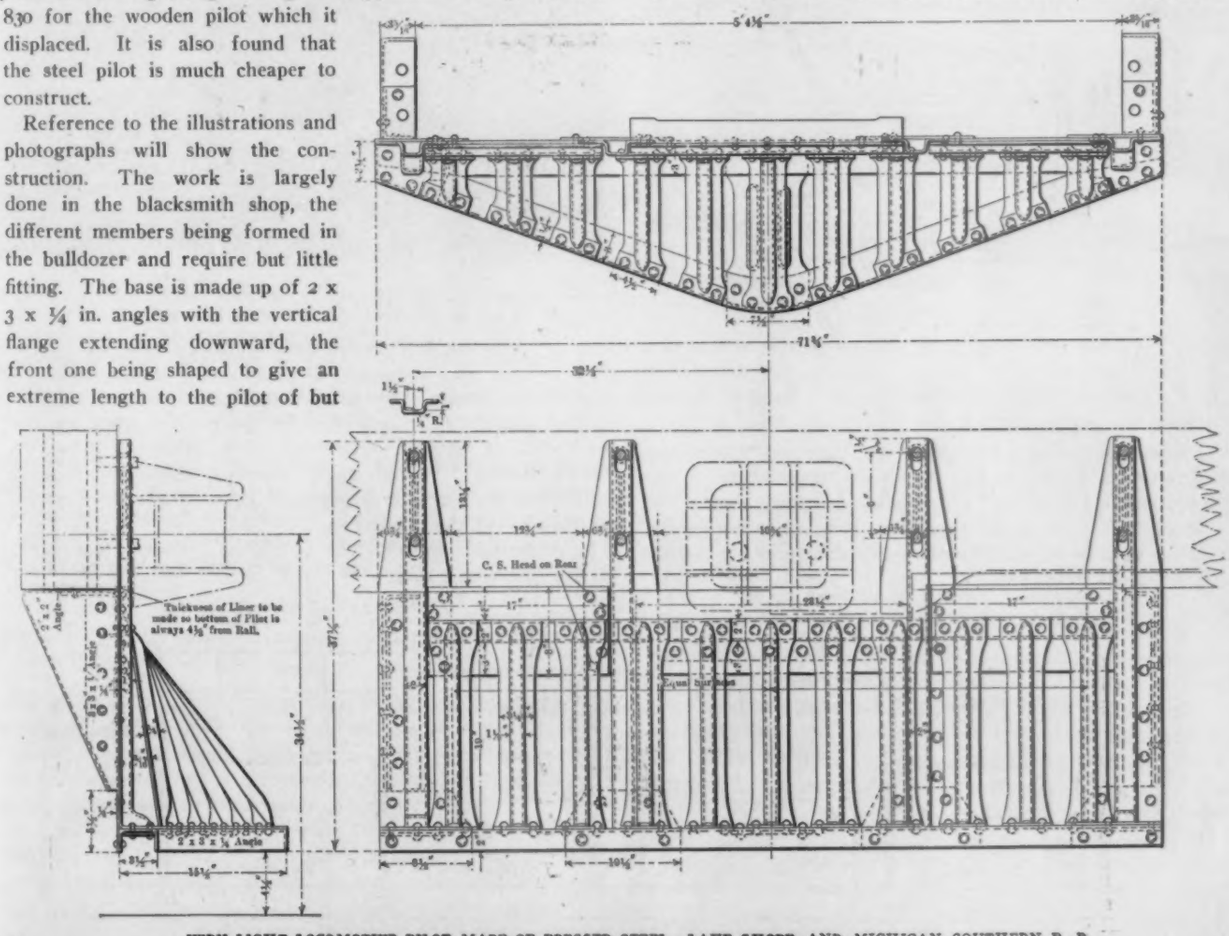


BACK OF STEEL PILOT.



GENERAL VIEW OF STEEL LOCOMOTIVE PILOT.

Reference to the illustrations and photographs will show the construction. The work is largely done in the blacksmith shop, the different members being formed in the bulldozer and require but little fitting. The base is made up of 2 x 3 x ¼ in. angles with the vertical flange extending downward, the front one being shaped to give an extreme length to the pilot of but 15½ in. The horizontal flanges of the angles are sheared off at the ends so as to fit together and a ¼ in. plate is provided for making the connection. There are also two horizontal pressed steel stiffening pieces from the nose of the pilot to the back angle. To the base is secured four pressed steel verticals which are flanged with a foot on the bottom to be riveted to the angle, and are further stiffened by a vertical plate in the back. The top bar consists of a ¼ in. plate pressed in form to give stiff-




VERY LIGHT LOCOMOTIVE PILOT MADE OF PRESSED STEEL—LAKE SHORE AND MICHIGAN SOUTHERN R. R.

ness and secured between the flat surface of the uprights. The centre plate is not as high as the two side ones and is reinforced by an angle on the back. Between the top bar and the base are riveted the pressed steel bars, which are flanged over on the bottom to give a strong and stiff connection to the base. The form and appearance of these bars is well shown in the illustrations.

The four brackets under the bumper are made up of 3 x 3 x ¼ in. angles reinforced by a ¼ in. flanged gusset plate. These extend well down toward the base of the pilot and are about 9 in. in length at the top. The holes in the uprights where they are secured to the bumper beam are slotted and liners can be inserted or removed from below the beam so as to always maintain the pilot at the proper distance from the rail.

## NEW LOCOMOTIVE REPAIR SHOPS.

### Wheeling & Lake Erie Railroad.

There is just being completed, at Brewster, Ohio, a new shop for repairing locomotives, which presents several novelties in design that makes it a most interesting study. It was designed by V. Z. Caracristi, consulting engineer, and is being erected by Westinghouse, Church, Kerr & Co.

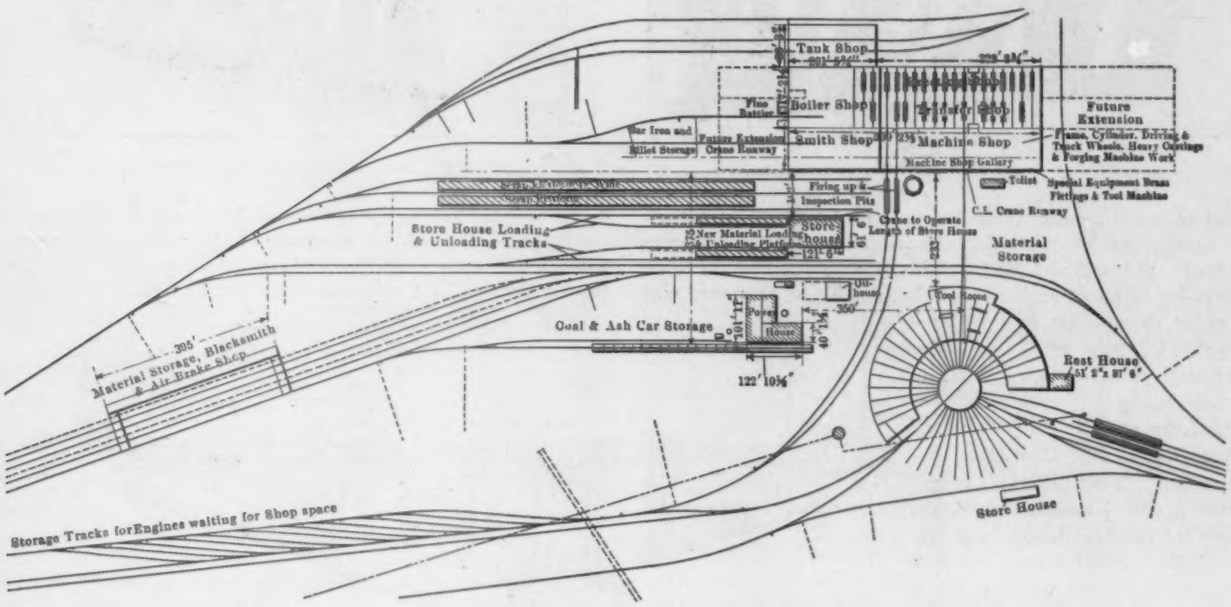
The shop plant proper consists of but three main buildings. One measuring 229 ft. by 530 ft. 2½ in. contains the erecting shop, machine shop, boiler shop and blacksmith shop. The tank shop, 88 ft. 3 in. by 201 ft. 5¾ in., is an extension on the side of the same building. The other two structures are a store house and a power house.

It is the large locomotive shop that presents the point of greatest interest, although the general arrangement of the whole plant is very carefully worked out. One of the illustrations shows a cross section of this building, in which it will be seen that it is divided into three principal bays. The erecting shop proper contains 16 pits in addition to two, in the same bay, which are in the boiler shop. Back of these is a bay served by a 150 ton crane, which is termed the transfer shop. The tracks from each of the erecting shop pits extend into this bay and several of them are provided with pits at this point. The next bay is the machine shop, served by a 10 ton crane over the heavy machines and having a gallery over the space for the lighter machines.

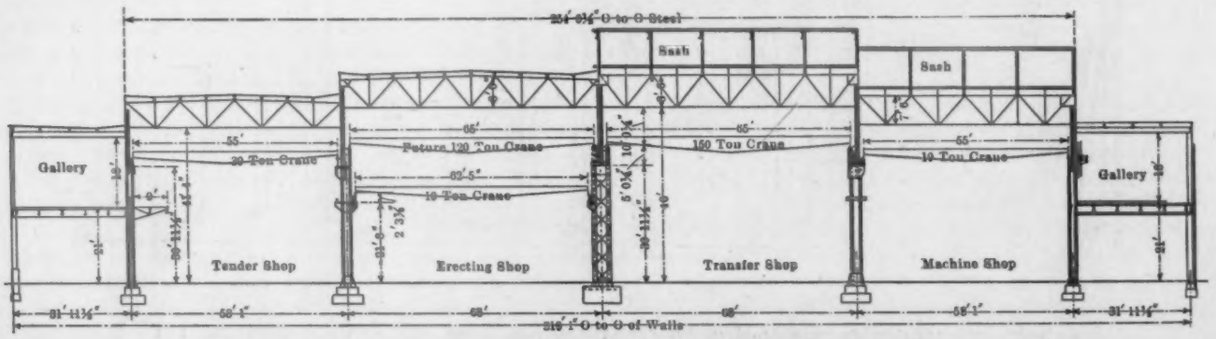
This arrangement is based on the idea of obtaining the advantages of a transverse erecting shop served by a transfer table and at the same time eliminating the serious disadvantages of the transfer table itself. This transfer shop, served by a 150-ton crane, has been installed to take the place of the table and locomotives coming into the shop are stripped in this space, removed from their wheels, set on lorry trucks and pulled into the erecting shop.

Here the erecting shop work is done up to the point of rewheeling, when they are pulled back into the transfer bay, rewheeled and finished. In this manner the space ordinarily taken up by a transfer table is utilized for the erecting work and for the storage of material taken from the locomotives. It permits the segregating of the stripping, wheeling, piping and painting work from the erecting shop proper and thus greatly increases the capacity of the plant.

In a later issue will be given a complete illustrated description of this interesting shop.




GENERAL ARRANGEMENT OF NEW LOCOMOTIVE REPAIR SHOP PLANT AT BREWSTER, OHIO—WHEELING AND LAKE ERIE R. R.




SECTION OF LOCOMOTIVE SHOP AT BREWSTER, OHIO.

# FOR THE SHOP SUPERINTENDENT AND FOREMAN.

SOME INTERESTING DEVICES AT THE READVILLE SHOPS OF THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD.

## MILLING CYLINDER BUSHING PORTS.

At the Readville shops a large vertical milling machine has been adapted for milling the ports in cylinder bushings. The arrangement consists of a plate mounted on the revolving table of the machine, which has a series of circular steps to fit inside of the different bushings. These are mounted vertically and

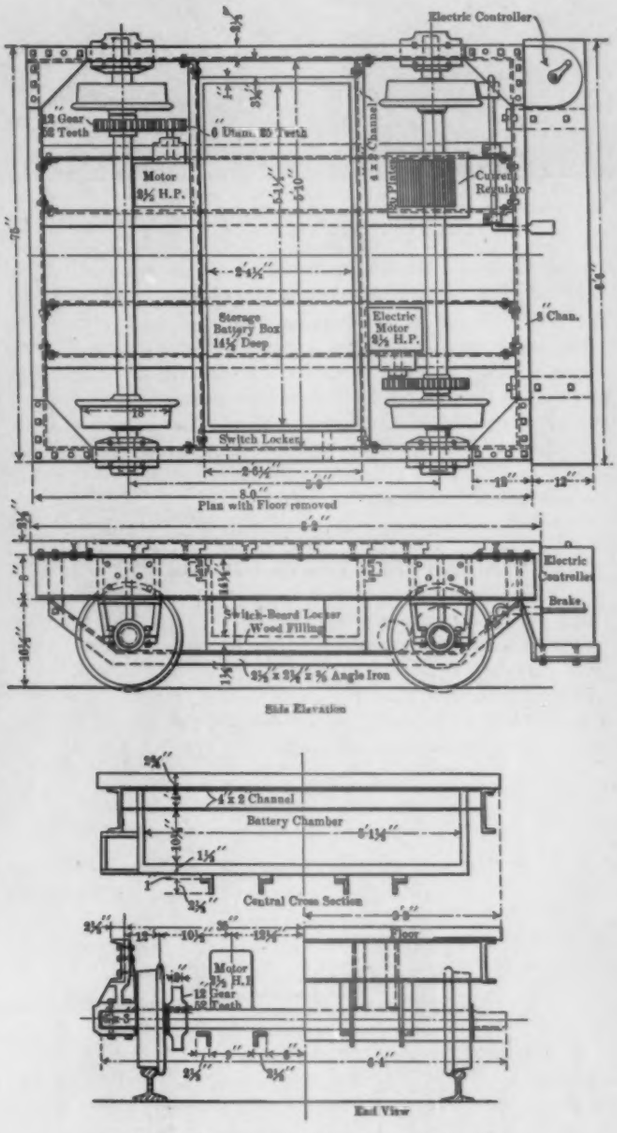
JIG FOR MILLING STEAM PORTS IN CYLINDER BUSHINGS. THE MILLING CUTTER HAS A VERTICAL ADJUSTMENT AND THE PLATE ON THE TABLE IS ARRANGED TO PERMIT THE QUICK AND EASY CLAMPING OF ALL SIZES OF BUSHINGS. THE CIRCULAR MOVEMENT OF THE TABLE IS AUTOMATIC AND THE PORTS ARE MILLED WITHOUT REQUIRING ANY DRILLING.

held by long bolts and straps across the top. A horizontal shaft carrying a milling cutter has been applied and is driven from the vertical shaft through a bevel gear. This cutter is also arranged to do the drilling, so that the whole operation of forming the ports in the bushings is done by one machine.

## ELECTRIC MOTOR TRUCK.

Normally railroad shop plants are not extensive enough to require a complete system of electric railway, such as are found in large industrial plants, but they are often so extensive that a large number of men are constantly employed pushing heavily laden trucks from one department to another.

At the Readville shops a storage battery electric truck has been built, which in addition to carrying its own load can also push several other loaded trucks. It is of a size suitable to fit the turntables and by its use the gangs of laborers are steadily employed in loading and unloading the trucks at the different points instead of pushing them around the plant.




DETAIL DRAWING OF ELECTRIC MOTOR TRUCK.

The design consists of a frame of steel channels and angles mounted on two pairs of 18 in. wheels, each axle being geared to a 2½ h.p. electric motor. A box 2 ft. 4½ in. wide and about 5 ft. long, supported in the center between the axles, is provided for the storage batteries. One end is fitted with a foot plate and an electric controller is located at one corner at this end. The controller permits operation in either direction and at several speeds. This truck is very powerful and has been found to be particularly convenient for lumber and heavy castings. A second one is now being built.

VIEW SHOWING THE CHIP BOX UNDERNEATH A CRANK PIN LATHE. THIS BOX IS MOUNTED ON ROLLERS SO THAT THE CLEANER CAN MOVE IT OUT OF THE WAY WITHOUT INTERFERING WITH THE WORKMAN.

## CHIP BOX FOR LATHES.

The accompanying illustration shows a simple design of a box which is placed underneath a lathe for catching the chips. It is mounted on swivel rollers and can be drawn out of the way and cleaned without interfering with the man working at the machine. It can be made waterproof if necessary, and has proven to be a most satisfactory arrangement under several of the machines at the Readville shops.

## CONTINUOUS FEED VALVE FOR AIR CYLINDER.

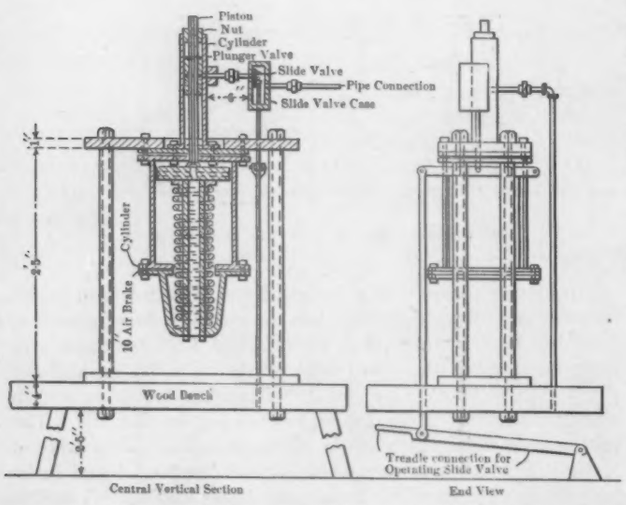
For use on a punching press operated by a 10 inch air brake cylinder a special design of feed valve has been designed, which gives a positive and continuous stroke of any length desired.

Reference to the illustrations will show that there is a piston rod extending up from the main piston through a small cylinder, which can be termed the valve cylinder. On this rod there are three plugs, the two outer ones being secured but adjustable as to length, and making a fit on the inside of the cylinder. The third is free to move on the rod and in the cylinder, but is fitted with leather packing to prevent leakage. It is mounted between the other two. The lower plug has five 7/16 in. holes through it, and there is also a ¼ in. hole from the top of the piston rod through its center connecting to an opening just above the lower plug. There are three large exhaust ports in the side of the cylinder, which at the bottom of the stroke are opened by the lower plug. Reference to the detailed illustration will show this construction.

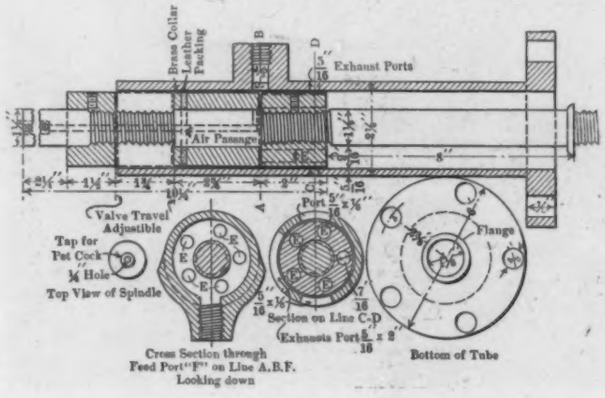
In the air line leading to the valve cylinder there is a small square box in which there is a small slide valve connected to a foot treadle. This opens or closes the air supply as desired.

The air being admitted at the port located just above the lower plug in the valve cylinder, when it is in the released position, passing through the openings in the latter, forcing the piston down until the rod in its downward movement moves the upper plug into contact with the center one and forces it downward sufficiently to close the air admission port. The exhaust ports will then be open and the spring will return the piston to the top of its stroke. As soon as the piston reaches its top limit the air port is again opened by the action of the lower plug and the stroke repeated, so continuing as long as the pressure is maintained.

This feed valve is in use at the Readville shops and assures a positive stroke to the press or punch, regardless of the work to be performed.




GENERAL ARRANGEMENT AND APPLICATION OF AUTOMATIC VALVE TO PNEUMATIC PUNCH.




DETAIL OF AUTOMATIC AIR VALVE FOR PNEUMATIC PUNCH.

GAS VS. GASOLENE FOR HEATING TIRES.—The following table gives the time and cost per average tire, or, better still, the actual cost per inch of diameter for heating locomotive tires, gasolene at $0.10 per gallon, commercial gas at $0.85 per 1,000 cubic feet.

| Inside diam. of tire. | Gasolene. | Commercial gas. |
|---|---|---|
| 42 in. | $0.1365 | $0.1143 |
| 44 " | .1431 | .1191 |
| 46 " | .1495 | .1251 |
| 52 " | .1690 | .1415 |
| 56 " | .1920 | .1523 |
| 62 " | .2015 | .1689 |
| 68 " | .2210 | .1850 |
| 74 " | .2405 | .2013 |
| Average time per tire | 17.52 min. | 15.5 min. |
| Average cost per tire | $0.176 | $0.1433 |
| Average cost per diameter, inch | .00325 | .00272 |

*—H. D. Kelley at the General Foremen's Convention.*

# TESTS OF JACOBS SUPERHEATER ON A TANDEM COMPOUND SANTA FE TYPE LOCOMOTIVE

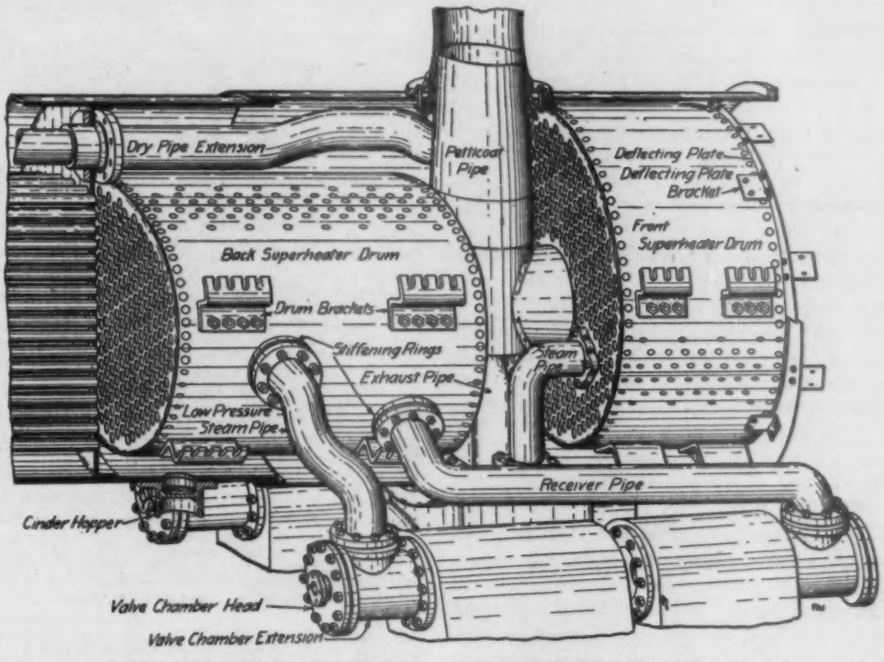
COMPLETE LOCOMOTIVE TESTS OF A TANDEM COMPOUND 2-10-2 TYPE OF LOCOMOTIVE FITTED WITH A JACOBS SUPERHEATER AND REHEATER AND AN IDENTICAL LOCOMOTIVE USING SATURATED STEAM. THE TESTS WERE MADE OVER A SECTION WHERE THE FULL CAPACITY OF BOTH LOCOMOTIVES WAS DEVELOPED.

Experience with the Baldwin smoke box superheater, as installed on quite a large number of freight locomotives on the Atchison, Topeka & Santa Fe Railroad, soon indicated that there was an opportunity of obtaining greater economy by the application of a superheater, which would give somewhat higher temperatures, coming within the limits of what would be called a moderate degree superheat. It was also indicated that, all things being considered, a superheater which does not require any deformation of the boiler was to be preferred.

To answer this purpose H. W. Jacobs, assistant superintendent of motive power, designed a fire tube drum type superheater which was applied to a locomotive in November, 1908. After a little over a year's performance the results indicated the superior qualities of this superheater over the low degree superheater as applied to other engines of the same class, and since that time the Jacobs superheater has been applied very generally to locomotives on the Santa Fe.

Since a large portion of the locomotives on this road are of the compound type, the superheater has been arranged in two parts, one drum being ahead of the exhaust pipe for superheating the steam on its way from the boiler to the high pressure cylinders and the other larger drum, located between the exhaust pipe and the front flue sheet acting as a reheater (see AMERICAN ENGINEER, December, 1909, page 481).

In June, 1909, engine 901, a tandem compound locomotive of the 2-10-2 type used on heavy mountain grades, was turned out of the Topeka shops equipped with a superheater of this type. One of the illustrations gives a perspective view showing the arrangement and connection of the superheater as applied to this locomotive. It consists simply of two steel drums, fitted with a series of horizontal fire tubes between the heads, located in the front end and the necessary steam pipe connections. In the earlier stages of the development of the superheater considerable experimental work was done to determine the proper diameter of fire tubes for the most satisfactory results. These researches indicated very strongly the superiority of the 2¼ in. tubes, which have since been used. The shells of the two drums are




JACOBS SUPERHEATER AS APPLIED TO TANDEM COMPOUND LOCOMOTIVE NO. 901.

⅝ in. boiler plate and the heads are flanged in the same manner as front flue sheets on locomotives. The rear drum is made oval in cross section to provide room for the passage of the dry pipe extension to the front drum, which is circular in cross section. The rear drum is placed about 24 in. ahead of the flue sheet and a manhole (not shown) provided in the bottom of the smoke box gives access to this space. There is a 6 in. central flue in the rear drum (not shown) in line with the 20 in. return flue in the front drum, permitting defective boiler tubes to be removed without taking out the superheater.

The rear drum, because of its situation directly in front of the flue sheet, is exposed to very high temperatures, subjecting the tube connection to severe expansion stresses. In order to prevent any possibility of trouble with leakage, the tubes in this drum are inserted without copper ferrules, rolled and expanded and are then welded at both ends by either autogenous or electric methods. It has not been found necessary to weld the tubes in

the front drum, which are rolled, expanded and beaded in the same manner as boiler tubes.

The two drums are as light as consistent with safety and are of very compact construction, giving a maximum volume and superheating surface per unit of weight. They are held in place by Z shaped brackets which are slotted and located so as to permit free expansion in all directions.

In the interior of both drums baffle plates of thin steel are inserted, being located to direct circulation equally over all of the tubes. These baffle plates direct the steam in such a manner as to give a scrubbing action over the surface of the tubes to remove the non-conducting film of highly superheated steam and thus permitting the greatest possible transmission of heat from the tubes to the steam. Deflector plates are placed around the back end of the rear drum to close the space between it and the front end shell and also around the forward head of the front drum, a space 18 in. wide at the bottom, however, being left open to prevent the accumulation of any cinders in the bottom of the smoke box. It will be seen that the gases from the boiler tubes must pass through both drums, are then reversed and turned through the large central flue in the front drum to an enclosed petticoat pipe which connects directly to the stack.

From the very start locomotive No. 901 with the superheater showed itself superior to other locomotives of the same class. It started quicker, hauled a greater tonnage, and used less fuel. While it has been generally conceded that superheated steam is of considerable value in passenger service, its economy in freight service at low speeds has not been definitely settled, and in order to determine its value under these conditions, arrangements were made for a thorough test of engine 901, operating under ordinary conditions of road service, and to make a similar test of another engine of the same class (No. 923) not equipped with a superheater, and thus get the comparative results to determine the value of superheated steam for compound freight engines.

The engines both belong to what is known as 900 class, which were designed and built by the Baldwin Locomotive Works, being of the 2-10-2 tandem compound type. They were first introduced on this road about eight years ago, and until the advent of the Mallet Articulated compound locomotives in this country, were the largest locomotives in the world. They were very fully illustrated and described in the following issues of this journal: October, 1903, page 372; November, 1903, page 398, and May, 1904, page 176. The general appearance is shown in the illustration indicating the location of the instruments and the general dimensions of both the locomotives under test are given in the table in the next column.

These locomotives are used in miscellaneous pushing and heavy freight service on the heavy grades of the Southwest, where the Santa Fe Railroad crosses five ranges of mountains, on which the maximum grades vary from 2 to 3½ per cent. Due to the heavy weight of the reciprocating parts they have a limited speed of 25 miles per hour. Greater speeds can be obtained, but at an increased expense for maintenance. Of these engines seventy are fitted as coal burners and 90 as oil burners. In starting heavy trains on 3 and 3½ per cent. grades they will exert a draw bar pull of 75,000 pounds, and can maintain a 45,000 pound draw bar pull at ten miles per hour on a 3 per cent. grade. The actual rating on through freight trains is given in the following table:

| Grade, feet per mile | Grade, per cent | Tonnage rating |
|---|---|---|
| 184.8 | 3.5 | 540 |
| 158.4 | 3.0 | 600 |
| 132.0 | 2.5 | 650 |
| 105.6 | 2.0 | 950 |
| 79.2 | 1.5 | 1150 |
| 52.8 | 1.0 | 1350 |
| 26.4 | 0.5 | 3300 |

No changes were made in the construction of engine 901 at the time of the application of the superheater except those necessary in the design of steam pipes and the moving of the front flue sheet back 42 in. While the shortening of the flues reduced the flue heating surface considerably, it did not prove to seriously affect the steaming qualities of the boiler. No changes were made in the valve setting, which is given in the table below.

It was necessary, of course, to entirely change the front end drafting arrangement of the locomotive with the superheater, as it does not require the use of any netting or baffle plate. Cinders and sparks striking against the two drums are whirled around the front of the front drum and by the time they leave the stack are extinguished. There are not as many sparks drawn into the front end as the draft is more constant and steady. Engine 901 was provided with a 5⅝ in. nozzle, while 923 required a 5¾ in. nozzle. This fact, however, is not apparent from the indicator cards, which showed that the size of the nozzle can be varied ¼ in. in diameter without materially affecting the back pressure.

Both locomotives were fitted with brick arches and tests were also made without arches, which, although they were not extensive enough to be conclusive, clearly indicated the great value of the arch as a fuel saver.

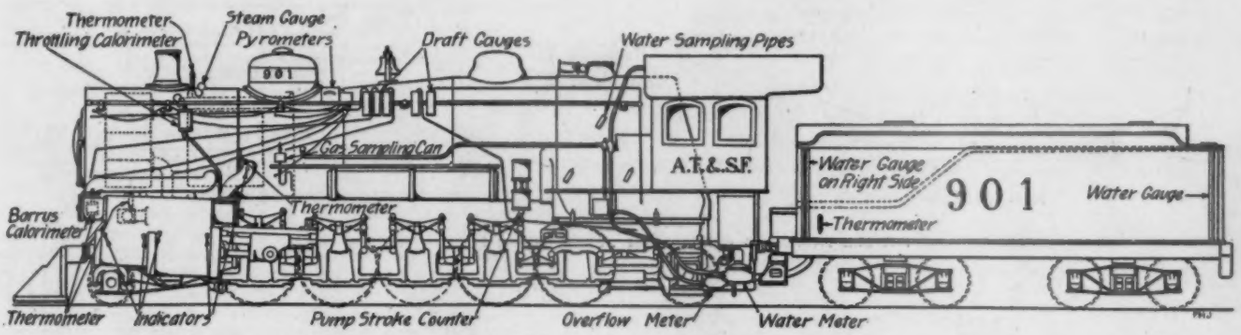
The general dimensions and valve setting of both these locomotives is given in the following table:

| | 901 | 923 |
|---|---|---|
| Engine Number | 901 | 923 |
| Weight in working order: | | |
| Tender, pounds | 165,800 | 165,800 |
| Drivers, pounds | 234,580 | 234,580 |
| Truck, pounds | 52,660 | 52,660 |
| Total, engine, pounds | 287,240 | 287,240 |
| Total, locomotive, pounds | 453,040 | 453,040 |
| Wheel base: | | |
| Rigid | 19 ft. 9 in. | 19 ft. 9 in. |
| Engine | 35 ft. 11 in. | 35 ft. 11 in. |
| Total | 66 ft. 0 in. | 66 ft. 0 in. |
| Tank capacities: | | |
| Water, gallons | 8,500 | 8,500 |
| Coal, pounds | 27,000 | 27,000 |
| Boiler: | | |
| Type—wagon top, radial stay, wide firebox. | | |
| Outside diameter, first ring, inches | 81.05 | 81.05 |
| Capacity, with water surface at level of second gauge cock: | | |
| Water space, cubic feet | 483.0 | 562.8 |
| Steam space, cubic feet | 84.2 | 94.6 |
| Flues: | | |
| Number | 391 | 391 |
| Outside diameter, inches | 2.25 | 2.25 |
| Thickness, inches | 0.125 | 0.125 |
| Length between sheets, inches | 197 | 239 |
| Total fire area, square feet | 3,360 | 4,077 |
| Arch—fire area, square feet | 12.8 | 12.8 |
| Firebox: | | |
| Length inside, inches | 104.25 | 104.25 |
| Width inside, inches | 78 | 78 |
| Depth front end, inches | 74.5 | 74.5 |
| Depth, back end, inches | 72.5 | 72.5 |
| Fire area, square feet | 209 | 209 |
| Total heating surface, based on inside of firebox and inside of flues, square feet | 3,582 | 4,299 |
| Grates, rocking finger—area, square feet | 58.5 | 58.5 |
| Ratio heating surface to grate area | 61.24 | 73.84 |
| Ratio fire area through flues to grate area | 0.147 | 0.147 |
| Ratio firebox heating surface to grate area | 3.57 | 3.57 |
| Ratio flue surface to firebox heating surface | 16.08 | 19.61 |
| Drivers: | | |
| Diameter, inches | 57 | 55.375 |
| Cylinders: | | |
| High pressure, right, diameter, inches | 19.125 | 19 |
| High pressure, left, diameter, inches | 19 | 19 |
| Low pressure, right, diameter, inches | 32 | 32 |
| Low pressure, left, diameter, inches | 32 | 32.5 |
| Stroke of piston, all cylinders, inches | 32 | 32 |
| Valves: | | |
| Type—piston valve. | | |
| Type of link motion—Stephenson, open rods. | | |
| Greatest valve travel, inches | 5.25 | 5.25 |
| Receiver volume: | | |
| High pressure superheater, cubic feet | 33.7 | |
| Low pressure superheater or receiver, cu. ft. | 34.5 | 6.0 |
| Dimensions of valve setting: | | |
| Steam ports, high pressure | 1⅝ in. | 1⅝ in. |
| Exhaust ports | 6 in. | 6½ in. |
| Bridge | 3¾ in. | 3¾ in. |
| Eccentric throw | 6 in. | 6 in. |
| Outside lap, high pressure | 1⅛ in. | 1⅛ in. |
| Outside lap, low pressure | ¾ in. | ¾ in. |
| Inside lap, high pressure, negative | ¼ in. | ¼ in. |
| Inside lap, low pressure, negative | ⅛ in. | ⅛ in. |
| Valve travel, front | 5⅝ in. | 5½ in. |
| Valve travel, back | 5 in. | 5⅛ in. |
| Saddle pin, set back | ¾ in. | ¾ in. |
| Lead full gear | line and line | line and line |

The tests were made on the first district of the Mexican Division of the Santa Fe between La Junta and Trinidad, Colo., a distance of 81.5 miles, of which 50 miles is an almost constant grade of 59.7 ft. per mile, the remainder having the same ruling grade, but all rolling.

Careful arrangements were made to obtain full data as to actual performance of engine relative to coal and water con-

sumption, quality of steam, boiler pressure, height of water in gauge glass, throttle and reverse lever positions, the drafts in the firebox and front end, degrees of superheat to cylinders, indicated horsepower, dynamometer horsepower, draw bar pull, speed and tonnage hauled. The diagrammatic arrangement of the apparatus as installed on the superheater locomotive is shown in one of the illustrations. The tests were made in actual mountain service with heavy tonnage trains. The engineer was instructed to make no difference in the general operation of the engine on account of tests and the regular engine crews, who had for a considerable time been assigned to the different engines were used, so that the results of tests might be more nearly in conformity to actual operations. The conditions of road service do not permit of a constant position of either reverse lever or throttle over the road, but require continual changing in position in order to maintain regular speed and prevent excessive draw bar pulls with long trains and consequent break-in-twos. As a consequence the records show considerable irregularity in performance on account of curves and grades. The average results, however, show considerable regularity in that there is such a correspondence in results recorded and grade conditions as to identify the operation of the engine on any particular portion of the trip. The special importance, then, to be laid on the records is that they contain in detail the history of all changes made and that readings were taken frequently enough to obtain this data.




LOCOMOTIVE NO. 901 AS EQUIPPED FOR ROAD TESTS.

TESTING APPARATUS.

*Coal Measurements.*—All the coal used for the various trips came from Willow mine number five, located at Hebron, New Mexico. One car load of coal was sacked at a time, each sack containing 200 pounds. Enough coal for each run was taken from the car of sacked coal and placed on the tender at terminals. Before beginning a test run, the condition of the fire was noted and care was taken that it was clean and even; at the end of the run the same condition was approached as nearly as possible.

The sacks were emptied to the fireman as needed, so that no more than 500 pounds of coal was open at any one time. The time of emptying each sack was noted, a careful record was kept of the number of shovels of coal used by the fireman as well as the time of firing. An exact record was kept of the number of shovels of coal fired.

Samples of coal from different sacks were taken during each test run, and from the accumulation of samples of fifty pounds a sample for each test was obtained by the standard method of quartering. The average samples thus obtained were analyzed and efficiencies for the runs were based upon the results of this analysis.

*Water Measurements.*—Three-inch Empire hot water meters were placed in each branch pipe; by-pass pipes for use when the engine was not under test were arranged to protect the meters. The meters were constantly checked by comparison with readings of gauge glasses on right front and left back corner of engine tank. Before the series of tests the engine tender was leveled and calibrated by weighing in water fifty gallons at a time. By leveling the tank and filling it with water and noting simultaneous readings of meter and tank gauges, the meters were calibrated and correction factors determined. The overflow of water from the injectors was discharged into calibrated cans, each of nine gallons capacity. As soon as the cans were nearly filled the amount was noted and cans were then emptied. A one and one-half inch Empire hot water meter was placed in the discharge from one of the overflow cans in order to check the method of measuring the overflow. The total amount of water overflowing from the injectors varied considerably on different runs and on different engines, depending very much upon the condition of the injectors. The amount of overflow was deducted from that shown by the injector meters, in determining the amount carried to boilers. No credit, however, was allowed for the heat in the water lost.

*Quality of Steam.*—The quality of the steam was determined at the dome for engine 923 and in the dry pipe extension for engine 901. The calorimeter was of the Peabody throttling type and of latest design for this work. The calorimeter itself was carefully lagged. The calorimeter for finding the quality of steam leaving the high pressure cylinders was of the separating type, a Barrus universal steam calorimeter of the 1895 type.

*Pressure Measurements.*—Crosby steam gauges were used in the cab and on the calorimeter. These gauges were tested constantly by means of the Crosby dead weight steam gauge tester. Pressures in the superheater and receiver of the engines were obtained by special piping to the steam indicators. A Short & Mason compensated barometer was used for taking atmospheric pressures. These pressures varied constantly during the trip on account of changes in elevation.

*Draft Measurements.*—"U" tubed draft gauges containing water were used in obtaining the drafts in the smoke box, between superheaters, in the firebox and in the ashpan. These gauges were bolted on the hand rail, and pipe connections were made to the gauge board from the various points where drafts were desired.

*Temperature Measurements.*—Thermal couples were used for measuring the smoke box temperatures. The Hoskins pyrometer was used for this purpose. The apparatus consisted of an eight-point switch with proper connections to front end. All the readings were taken from one instrument fastened on the hand rail. The couples themselves were of one-sixteenth inch material, and were very sensitive to changes in temperature, so that differences in temperature in gases at top or bottom of smokebox were shown almost immediately. The pyrometer itself was so substantial in construction that after several months of service it showed upon test to be registering accurately.

An angle thermometer reading up to 212 degrees was used in obtaining temperatures of feed water. This thermometer was placed in the front of the engine tender close to suction pipe. Thermometers reading up to 600 degrees Fahrenheit were used in determining the superheat of steam to cylinders. These thermometers were tested from time to time against standard thermometers and proper corrections made.

POWER MEASUREMENTS.

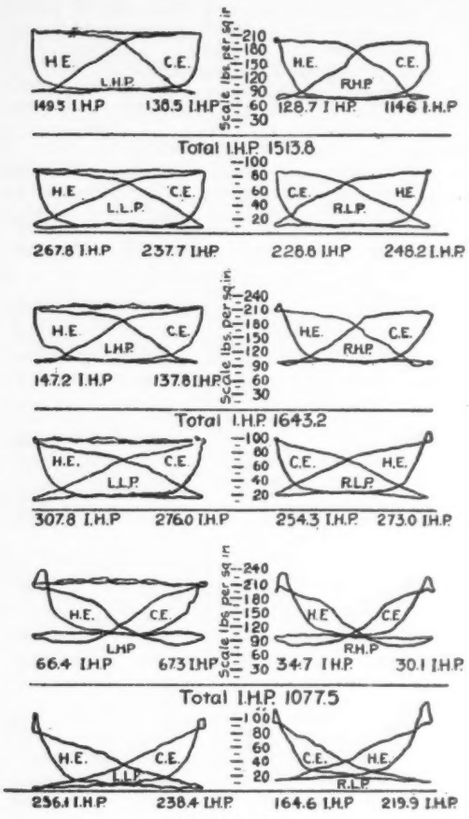
*Indicated Horse Power.*—The latest type of Crosby continuous outside spring indicators were used. The springs were tested before each series of runs. The indicators themselves were carefully tested for parallelism at various times throughout the tests, and were constantly tested for free, easy pencil movement, since in a series of road tests there is more or less dust or sand to interfere with operation of indicators.

While thirty-six cards may readily be taken at one time with the continuous indicator, yet it was found, after numerous trials, that three showed very accurately the information desired. Three were taken at each reading, and in working up the data the middle card was used as a sample; the other two cards indicating that the conditions just before and after taking the card differed not greatly from that at the time of taking the card. Cards were taken from all four cylinders simultaneously and connections were made to the dynamometer car so that an offset was made on the chart registering the beginning and end of each period of taking cards. This method of registering indicated accurately the location on road where cards were taken.

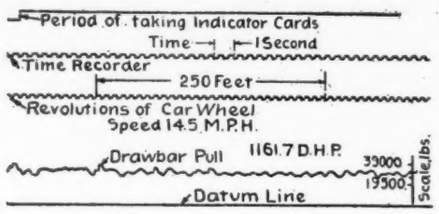
The indicator reducing motion was of the slotted lever type, which took its motion from the engine cross-head and in turn drove a small cross-head. The second cross-head had a light tube or motion rod. On this tube were adjustable fingers to which the indicator drum cords were attached.

*Dynamometer Horse Power.*—To determine accurately the work done by the engine and the resistance of the different trains, a dynamometer car was used. This car is known as the Westinghouse Air Brake Car number five, and was obtained from the Westinghouse Company for making this series of tests. The dynamometer itself is of the diaphragm type and is capable of recording very high drawbar pulls and buffs.

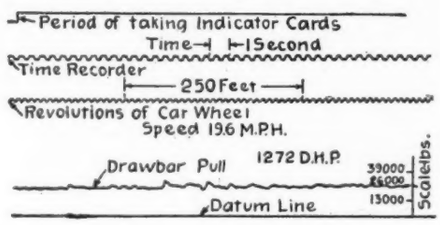
The record of performance as shown on the twelve-inch roll attached to the chronograph shows very distinctly the variations in drawbar pulls at quarter second intervals. Time measurements of one-half seconds were shown by offsets in line on left side of the paper. Distance measurements in revolutions of the wheels were shown on the right side of the paper by offsets in pen line. The diameter of the wheel is such that the number of revolutions of the axle in six seconds gives the speed in miles per hour. The paper also records a base line upon which distance signals were recorded by an offset in the line, made by breaking the circuit on the part of the observer. Mile posts, time and stations were written on the chart.



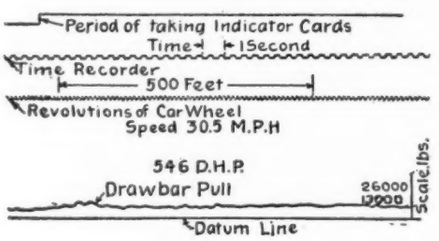

**Records at Mile Post 575**



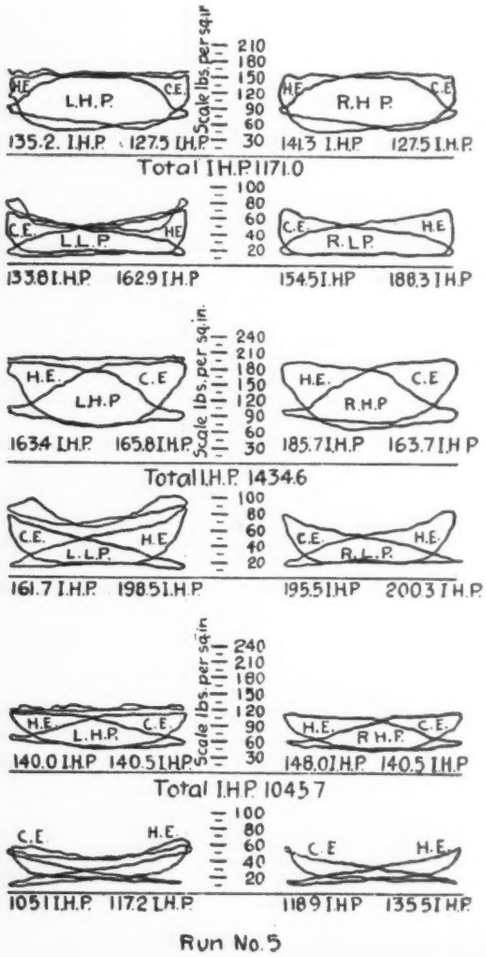

**Records at Mile Post 594**



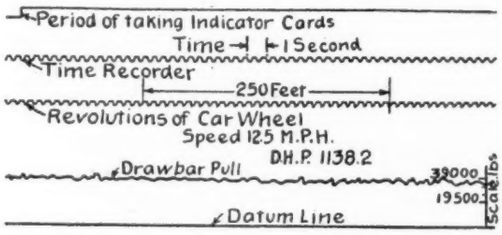

**Records at Mile Post 625**




SAMPLE INDICATOR CARDS FROM SUPERHEATER LOCOMOTIVE NO. 901.




**Records at Mile Post 575**

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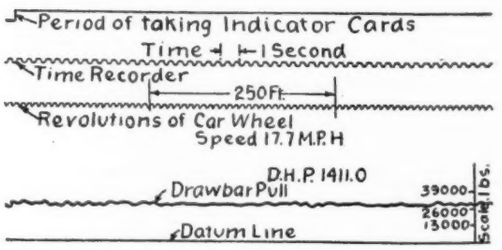
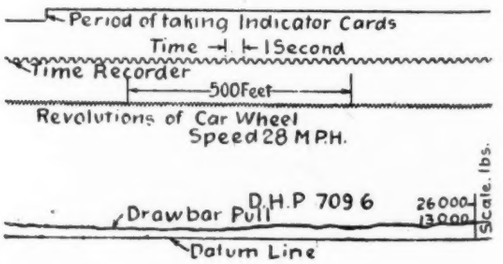



**Records at Mile Post 625**




SAMPLE INDICATOR CARDS FROM LOCOMOTIVE NO. 923.

A separate base line is used for recording of time during which indicator cards were taken. All data regarding dynamometer horse power, drawbar pull and speeds were obtained from the charts in the dynamometer car.

TONNAGE MEASUREMENTS.

The tonnage haul was taken from the conductor's wheel report. These reports show weight in cars as per waybills, and also light weight of cars. The light weights of cars were invariably checked by noting the actual light weight stenciled on cars in train and comparing them with the wheel report. In all cases the tonnage refers to the number of tons in the train and does not include tonnage of tender and engine.

OBSERVATIONS.

The determining of points at which readings should be taken is of great importance in road tests where results serve to indicate average performance. Even on up grades, such as in a territory between La Junta and Simpson, there are a great many momentum grades. On this account it is a difficult problem to choose points at which observations should be taken that will indicate, with any degree of fairness, the real performance of the engine.

In order to assure uniformity of readings, certain mile posts were chosen and the different observations were made at these mile posts. By such an arrangement the readings made served for an average performance obtained during the trip. The indicator cards were taken on an average of thirty times per run. The pyrometer, calorimeter, drafts, temperatures, height of water and boiler pressures were taken on an average of forty times per trip, throttle and reverse lever positions were noted for each change. Water meters were read at every mile post where indicator cards and calorimeter readings were taken, and also at the top and bottom of grades as well as at the time of stopping and starting of engine. The dynamometer readings were taken continuously from the start to the end of each trip, excepting on the trips from Trinidad to La Junta. On these runs the dynamometer records were cut out at Thatcher. The number of shovels of coal was recorded as fired; the number of sacks of coal, as emptied.

INDICATOR CARDS.

The application of a superheater between the high and low pressure cylinders of a tandem compound locomotive affords an opportunity for studying the effects of a large receiver volume on the distribution of indicated horse power between the high and low pressure cylinders for various engine speeds.

On the non-superheater locomotive, the receiver volume between the high and low pressure cylinders is very small, only amounting to six cubic feet, and furthermore the cylinder receivers on each side of the locomotive are entirely separate. The high pressure exhaust line follows closely the low pressure admission line and with equal ratios of cut-off, the ratio of indicated horse power in the two cylinders is nearly unity, averaging 1 to 1:21 for the entire runs. Any increase in speed tends to bring the ratio closer to unity so that both high and low pressure cylinders develop nearly the same amount of power.

Due to small receiver volume, the receiver pressure fluctuates greatly and records with distinctness the characteristic events of the stroke. On the superheater locomotive the receiver between the high and low pressure cylinders has a capacity of 34.5 cubic feet. Both high and low pressure cylinders exhaust into the one receiver at different quarters of the stroke, and thereby maintain a comparatively high receiver pressure. With the aid of the starting valve the pressure is raised to a maximum in one stroke. As soon as this pressure is attained, the back pressure line of the high pressure cylinders becomes a straight line parallel to the atmospheric line. While its height depends entirely on how hard the engine is working, yet it is never slanted downward nor does it follow the low pressure admission line as in the other locomotive.

Both high pressure cylinders exhaust at different times into a common receiver. Due to the large volume of this receiver, the admission line on the low pressure is maintained more nearly horizontal than on the engine without large receiver volume. The receiver is a superheater and also serves to re-evaporate water condensed in the high pressure cylinders, thereby greatly increasing the volume of the exhaust steam from the cylinders as well as making a further increase in volume by superheating. Accordingly there is always a tendency for an increase in the back pressure in the high pressure cylinders. These conditions cause an increase of pressure in the high pressure cylinder, reduce the mean effective pressure in the high and increase it in the low pressure cylinders, thereby increasing the horse power ratio between the two cylinders from 1 to 1.98 for the average of the entire runs. The lower the speed the more even the division of power. The higher the speed the greater the ratio in favor of the low pressure cylinder.

This distribution of power made engine 901 slightly more powerful at slow and average speeds than engine 923. At high speeds, however, the difference in power was less perceptible. The gain in horse power in the low pressure cylinder more than offset the loss in the high pressure cylinder, both at high and low speeds. The influence of a large receiver on starting is a most important one. If the starting valve is not sufficiently large or there is not a by-pass allowing steam at boiler pressure to enter the receiver through a quick opening valve the engine will be so slow in starting that the insufficient engine momentum acquired will be inadequate to start a heavy train. On this engine the simpling or starting valve was large enough so that the large volume receiver was quickly filled with steam at a good pressure. The first low pressure cards taken at starting showed from one-fifth to one-fourth more horse power than cards immediately following. This condition for starting made the engine exceptionally powerful, so that when necessary to stop for switching or for section men on steep grades or on bad curves, there was no great difficulty in starting the train. Other engines of her class under such conditions of stopping usually have to back up and run for the grades.

The indicator cards for engine 923 are typical cards for engines of this design, though the lead on cards at slow speed does not seem in all cases to be sufficient. The indicator cards of engine 901 are such as should be expected at slow speeds. At high speeds, however, there was considerable negative work in the high pressure cylinders, part of which was due to lack of lead and excessive compression and part to the way in which both high pressure cylinders exhausted at different times into the one receiver.

TEST RUNS.

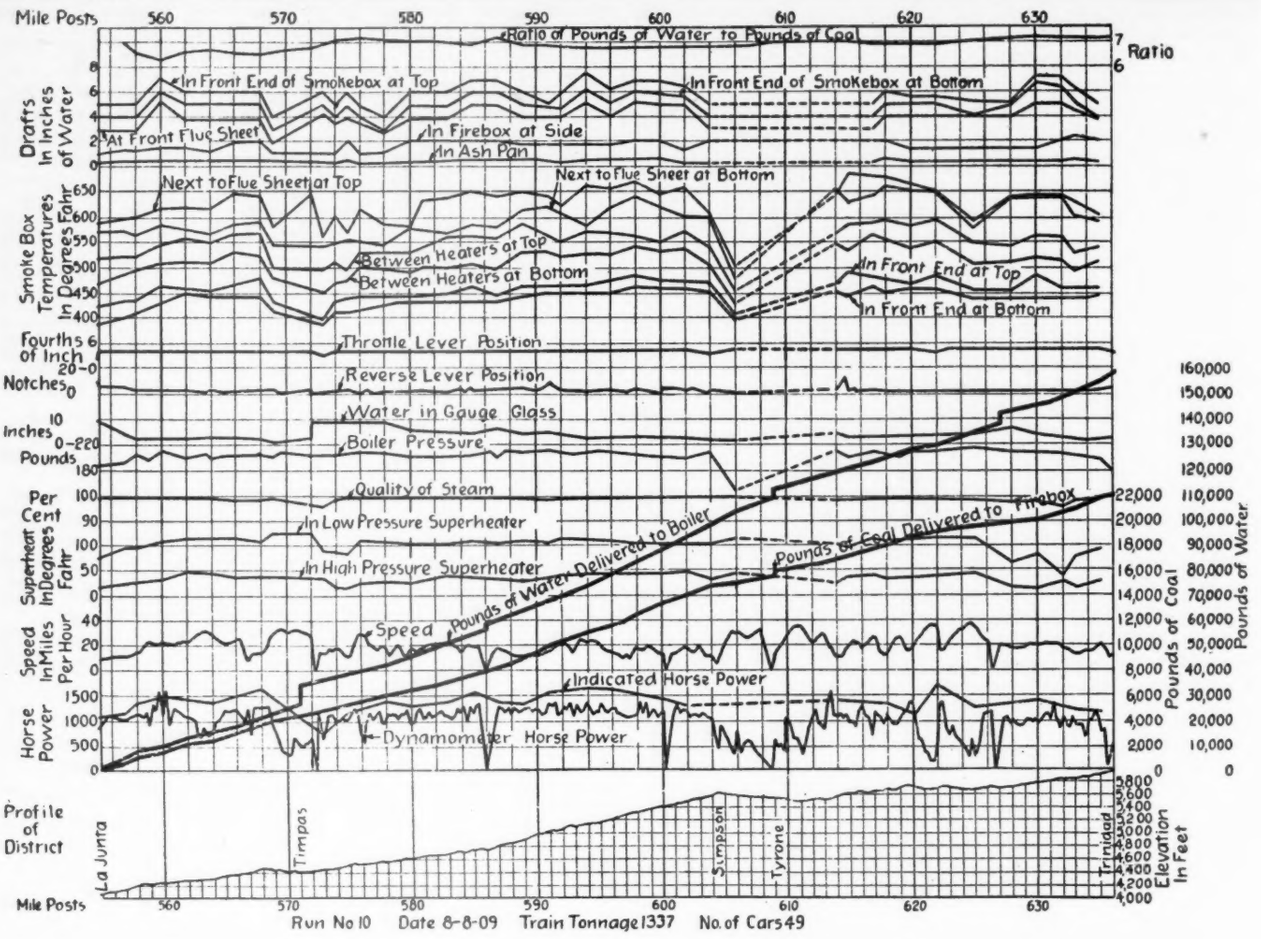
*Preliminary Runs.*—Several preliminary runs were made to determine the best drafting conditions and make such adjustments in test apparatus as to record specific data needed. The test runs were then made under the normal conditions prevailing and with such tonnage as available and under such condition of service, either through or local freight, as consistent with operative conditions.

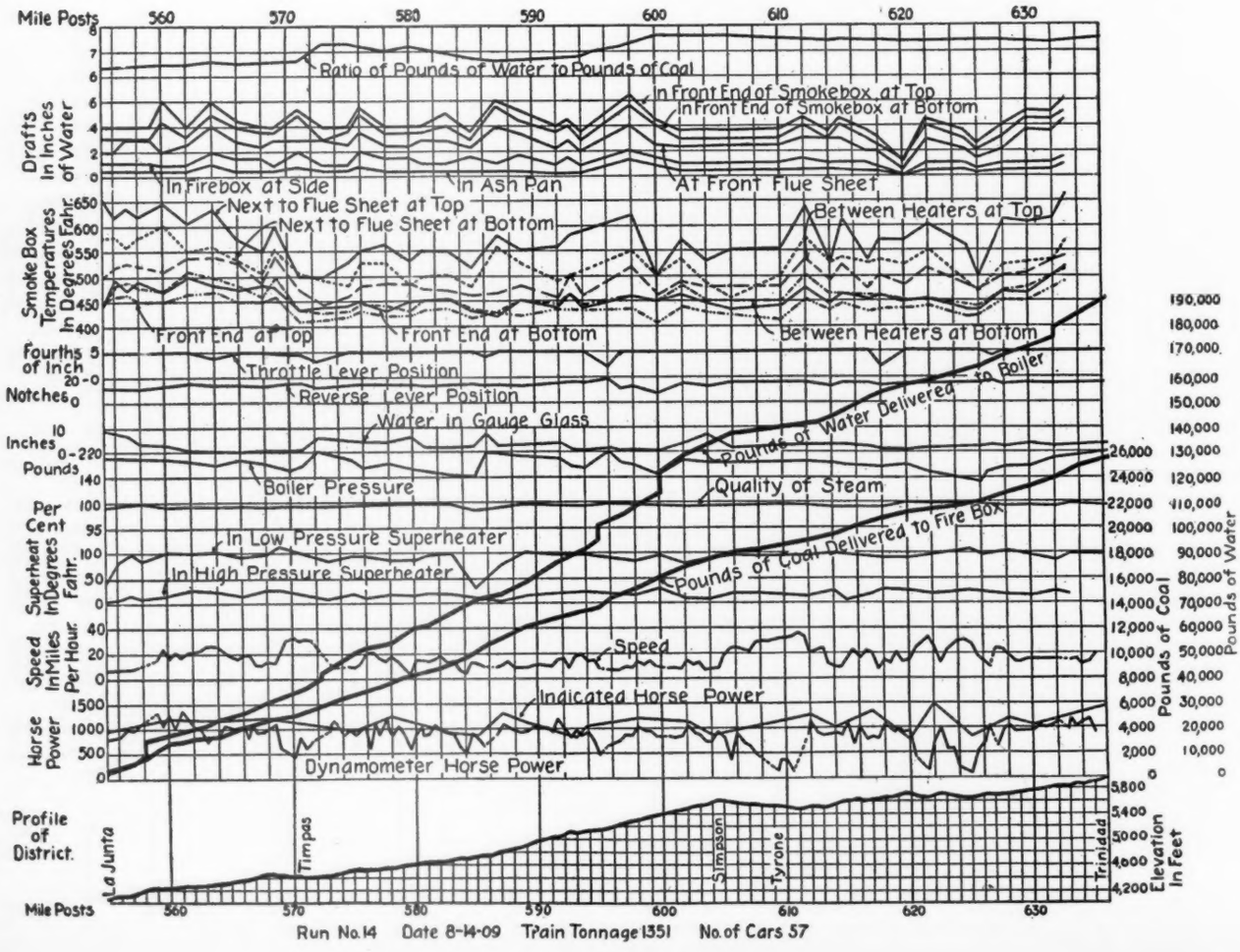
*Run No. 7, Engine 901.*—This run was made from Trinidad to La Junta on August 4th. There were 2,875 tons in the train, consisting of sixty-five cars. The total time on the road was five hours and forty-two minutes. The total delayed time was one hour and thirty-eight minutes, leaving an actual running time of four hours and four minutes. Ten thousand one hundred pounds of coal were used during this trip, with an average coal consumption of 43.1 pounds of coal per thousand gross ton miles. The ashes removed at the end of the run amounted to 1,364 pounds; the ashes in the coal as fired as shown by analysis amounted to 1,044 pounds; 74,177 pounds of water were supplied to the boiler. The equivalent evaporation was 8.82 pounds of water per pound of coal, but by crediting the heat imparted by the waste gases to the superheaters, this was increased to 9.5 pounds of water per pound of coal. The theoretical evaporation for the coal used on the trip was 13.77 pounds of water per pound of coal, so that the boiler efficiency was 69 per cent. for the run.

The maximum temperature of steam to high pressure cylinder was 418 degrees, that to low pressure cylinder was 448 degrees. The maximum superheat in high pressure cylinders was 39 degrees, in low pressure cylinders 105 degrees.

*Run No. 9, Engine 901.*—The run was made from Trinidad to La Junta on August 7th. There were 3,009 tons in the train of eighty-one cars. The total time on the road was seven hours and twenty-eight minutes; the total delayed time was three hours, so that the actual running time was four hours and twenty-eight minutes. The causes for such unusual delays as occurred on this trip were due mostly to a broken knuckle and hot boxes on cars in train. During periods of delay 1,200 pounds of coal were consumed. The total coal consumed for the run amounted to 9,300 pounds, or 37.9 pounds per thousand gross ton miles. The total ash removed was 1,346 pounds, while that in the coal as fired, as shown by analysis, was 1,201 pounds. Sixty-nine thousand eight hundred and thirteen pounds of water were evaporated, which gives an equivalent evaporation from and at 212 degrees of 8.93 pounds of water per pound of coal fired. Giving credit to heat taken up in superheating steam, the equivalent evaporation is increased to 9.62 pounds of water per pound of coal. The theoretical evaporation per pound of coal used during this trip was 13.63 pounds, so that the boiler efficiency for the trip was 70.6 per cent.

*Run No. 10, Engine 901.*—The run was made on August 8th, from La Junta to Trinidad, with a train of 1,337 tons in 49 cars. The total time on road was six hours and seven minutes, the delayed time was one hour and fifty-two minutes, so that the actual running time was four hours and fifteen minutes. The coal consumed on the run was 21,833 pounds; this performance showed a consumption of 200.3 pounds of coal per thousand gross ton miles. For a distance of 32.3 miles from Timpas to Simpson, the coal consumed was 238.7 pounds per thousand gross ton miles; 156,421 pounds of water were delivered to the boiler, so that the equivalent evaporation of water per pound of coal was 8.23. This figure was increased to 8.79 by crediting the amount of heat yielded by the waste flue gases in superheating steam. The theoretical evaporation from coal used on this trip


Mile Posts
Ratio of Pounds of Water to Pounds of Coal
Ratio
Drafts In Inches of Water
In Front End of Smokebox at Top
In Front End of Smokebox at Bottom
At Front Flue Sheet
In Firebox at Side
In Ash Pan
Smoke Box Temperatures In Degrees Fahr
Next to Flue Sheet at Top
Next to Flue Sheet at Bottom
Between Heaters at Top
Between Heaters at Bottom
In Front End at Top
In Front End at Bottom
Fourths of Inch
Throttle Lever Position
Notches
Reverse Lever Position
Inches
Water in Gauge Glass
Pounds
Boiler Pressure
Per Cent
Quality of Steam
Superheat In Degrees Fahr
In Low Pressure Superheater
In High Pressure Superheater
Speed In Miles Per Hour
Speed
Pounds of Water Delivered to Boiler
Pounds of Coal Delivered to Firebox
Horse Power
Indicated Horse Power
Dynamometer Horse Power
Pounds of Coal
Pounds of Water
Profile of District
La Junta
Trimpas
Simpson
Tyrone
Trinidad
Elevation In Feet
Mile Posts
Run No 10 Date 8-8-09 Train Tonnage 1337 No. of Cars 49


Mile Posts
Ratio of Pounds of Water to Pounds of Coal
Drafts In Inches of Water
In Front End of Smokebox at Top
In Front End of Smokebox at Bottom
In Firebox at Side
In Ash Pan
At Front Flue Sheet
Smoke Box Temperatures In Degrees Fahr
Next to Flue Sheet at Top
Next to Flue Sheet at Bottom
Between Heaters at Top
Front End at Top
Front End at Bottom
Between Heaters at Bottom
Fourths of Inch
Throttle Lever Position
Notches
Reverse Lever Position
Inches
Water in Gauge Glass
Pounds
Pounds of Water Delivered to Boiler
Boiler Pressure
Quality of Steam
Per Cent
In Low Pressure Superheater
Superheat In Degrees Fahr.
In High Pressure Superheater
Pounds of Coal Delivered to Fire Box
Speed In Miles Per Hour
Speed
Horse Power
Indicated Horse Power
Dynamometer Horse Power
Pounds of Coal
Pounds of Water
Profile of District.
La Junta
Trimpas
Simpson
Tyrone
Trinidad
Elevation In Feet
Mile Posts
Run No. 14 Date 8-14-09 Train Tonnage 1351 No. of Cars 57

was 13.7 pounds of water per pound of coal, so that the boiler efficiency for the trip was 64.3 per cent.

The maximum temperatures of steam to high pressure cylinders was 428 degrees, that to low pressure cylinders was 453 degrees. The maximum superheat to high pressure cylinders was 50 degrees, that to the low pressure cylinders 140 degrees. The average number degrees superheat to the high pressure cylinders was 24.4 degrees, that to the low pressure cylinders was 102.2 degrees.

All data relative to the performance of engine on this trip is graphically plotted and shown in the illustration. This chart also includes a profile of the district showing elevation in feet above sea level at different points on the road. Among other things this chart shows at different points of observation the dynamometer and indicated horsepower, the speed in miles per hour, the degrees superheat in both high and low pressure cylinders, the quality of steam, the boiler pressure, the temperatures in smoke box, etc.

The highest continuous drawbar pull exerted during this run was 39,050 pounds at a speed of ten miles per hour. At 12.8 miles per hour, the engine exerted a drawbar pull of 38,550 pounds at the back of the tender; at twenty miles per hour, a drawbar pull of 30,950 pounds was exerted.

*Run No. 12, Engine 901.*—The run was made from La Junta to Trinidad on August 11th with 1,328 tons contained in forty-six cars. The total time on road was seven hours and two minutes; the total delayed time was one hour and forty-four minutes, so that the actual running time was five hours and eighteen minutes. A total of 22,048 pounds of coal were fired on the trip and 158,355 pounds of water were supplied to the boiler, so that the equivalent evaporation from and at 212 degrees was 8.22 pounds of water per pound of coal. Giving credit for heat regained from waste gases in superheating steam, the equivalent evaporation is raised to 8.81 pounds of water per pound of coal, so that the boiler efficiency attained for the run is 65.8 per cent. The fuel consumed for the total run averaged 203.8 pounds of coal per thousand gross ton miles. On the heavy stretch from Timpas to Simpson, the fuel consumed averaged 250 pounds of coal per thousand gross ton miles. The boiler efficiency for this portion of the trip was 64.8 per cent. The maximum temperature attained in the high pressure steam was 422 degrees and in the low pressure steam 432 degrees. The maximum superheat in the high pressure steam was 35 degrees and in the low pressure 105 degrees. Engine gave a drawbar pull of 39,740 pounds at a speed of 12.7 miles per hour. At a speed of sixteen miles per hour, a drawbar pull of 32,490 pounds was developed, while at a speed of twenty-six miles per hour, a drawbar pull of 19,530 pounds was exerted. At mile post 617, the engine showed 1,937 indicated horsepower at twenty-six miles per hour, and developed 1,354 drawbar horsepower. This power was developed under accelerating conditions.

*Run No. 13, Engine 901.*—This run was was made on August 13th, with 3,166 tons contained in 59 cars. The total time on road was five hours and forty-five minutes, delayed time one hour and forty minutes, so that the actual running time was four hours and five minutes. On this run 8,300 pounds of coal were fired, so that the average consumption of coal was 32.2 pounds per thousand gross ton miles, which was the best record obtained on down grade runs.

The water supplied to the boiler amounted to 61,801 pounds. The evaporation at the dome, from and at 212 degrees, was 8.62 pounds of water per pound of coal. This evaporation was further increased, on account of heat absorbed from waste gases in superheating steam, to 9.15 pounds of water per pound of coal. The heat value of the coal used was considerably less than on previous trips. The coal itself had a theoretical evaporative value of 13.25 pounds of water per pound of coal, so that the efficiency of the boiler was 69 per cent. The maximum temperature of steam to high pressure cylinders was 408 degrees, that to low pressure cylinders was 439 degrees. The maximum superheat in high pressure steam was thirty-two degrees and that in low pressure steam was 110 degrees.

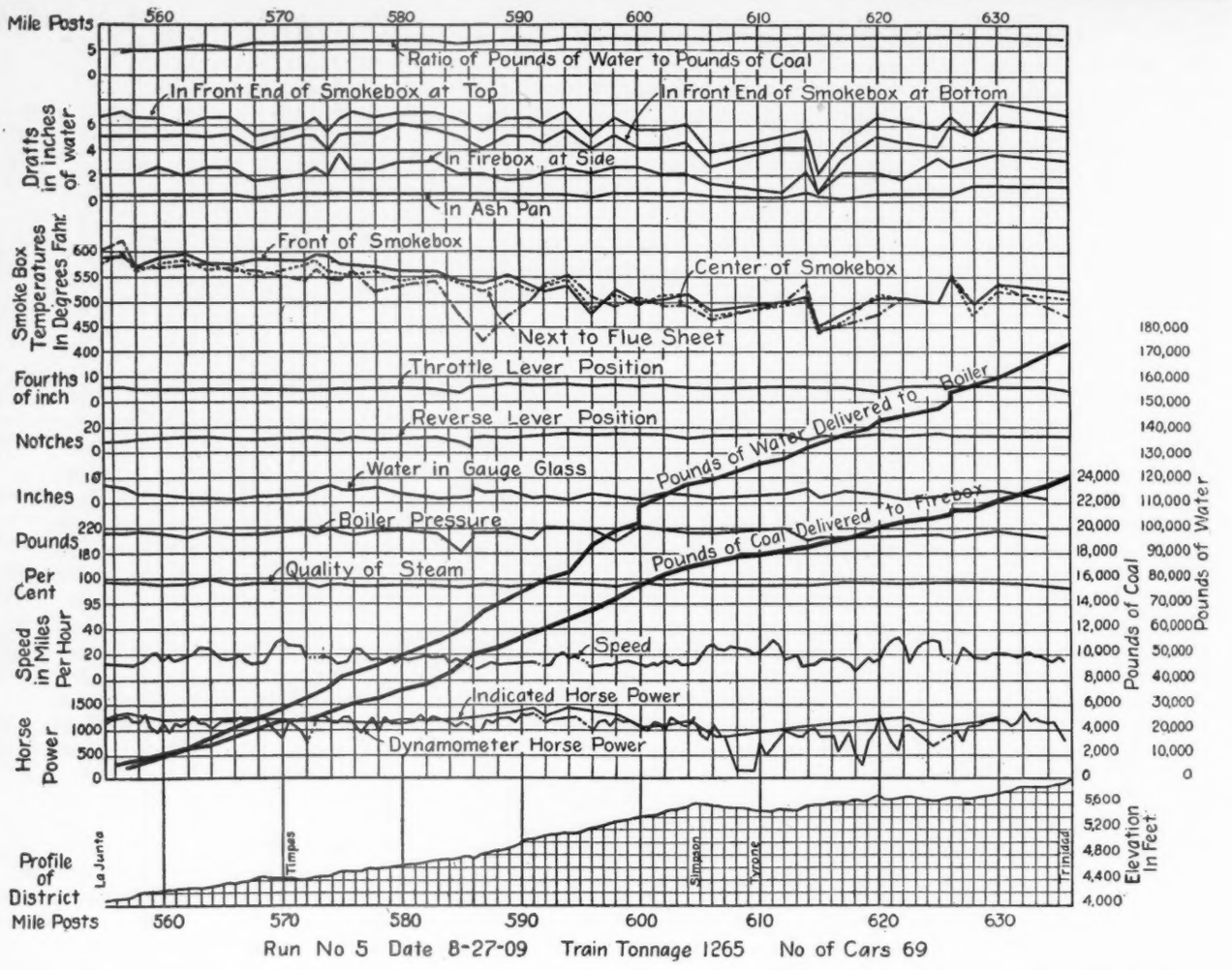
*Run No. 14, Engine 901.*—The run from La Junta to Trinidad was made on August 14th with 1,351 tons in fifty-seven cars. All of the previous runs of this engine were made with arch brick equipment. The principal object of this run was to determine the bearing that the arch brick equipment had on general performance and to determine the relative economy of this equipment. The coal consumption for this run was 25,511 pounds, so that the average consumption was 231.7 pounds of coal per thousand gross ton miles. The water supplied to the boiler amounted to 185,980 pounds. The evaporation from and at 212 degrees was 8.37 pounds of water per pound of coal, but this was increased to 8.89 pounds upon crediting to the boiler the amount of heat absorbed in superheating steam from the waste gases.

The maximum temperature of the steam to high pressure cylinders was 405 degrees, that to the low pressure cylinders 438 degrees. At a speed of twenty-six miles per hour the engine exerted a drawbar pull of 40,430 pounds. At a speed of 16.7 miles per hour, a drawbar pull of 28,860 pounds was recorded.

*Run No. 2, Engine 923.*—The run was made on August 22nd, from Trinidad to La Junta with 3,171 tons in sixty-two cars. The total time on road was seven hours and forty-two minutes, the delay was three hours, so that the actual running time was four hours and forty-two minutes. Two delays occurred during the trip on account of breaking of train equipment, one of one hour on account of a broken knuckle and one of twenty minutes on account of a drawbar pulled out. During these periods six hundred pounds of coal were fired. The total coal consumption for the run was 11,370 pounds. The average coal consumption per thousand ton miles was 44.1 pounds. The total water supplied to the boiler was 74,340 pounds. The evaporation from and at 212 degrees was 7.25 pounds of water per pound of coal. The theoretical evaporation of the coal used for the trip was 14.1 pounds of water per pound of coal, so that the boiler efficiency was 51.4 per cent. The ash in the coal as fired amounted to 1,413 pounds, while there were removed from the ashpan 1,979 pounds of ash.

*Run No. 3, Engine 923.*—The run was made on August 24th from La Junta to Trinidad with 1,126 tons in fifty cars. The total time on road was eight hours and fifty-five minutes, the delayed time was two hours and thirty-eight minutes, so that the actual running time for the trip was six hours and seventeen minutes. On this run, as on run number two, the engine did not have arch brick equipment. One object of the run was to determine the value and efficiency of the arch brick equipment so far as fuel consumption was concerned. The results of the run on this account are more properly compared with those obtained on run number fourteen of engine 901. The total coal consumed for the trip amounted to 26,988 pounds. The average fuel consumption per thousand ton miles was 317.2 pounds of coal, which was greatly in excess of figures obtained on any other run. The total water supplied to the boiler was 172,907 pounds. The equivalent evaporation from and at 212 degrees was 7.33 pounds of water per pound of coal. The boiler efficiency for the run was 52.2 per cent. At a speed of 12.4 miles per hour a drawbar pull of 33,350 pounds was exerted. At 16 miles per hour, the drawbar pull was 27,990 pounds; at 19.3 miles per hour, the drawbar pull was 21,080 pounds. On the territory from Timpas to Simpson 3.11 pounds of coal were burned for each million foot pounds at the drawbar, and 74,730 heat units in the coal were consumed per drynamometer horsepower per hour. These figures are considerably higher than results obtained on any other test runs.

*Run No. 4, Engine 923.*—The run was made August 25th from Trinidad to La Junta with 3,062 tons in 51 cars. This was the first trip by engine with arch brick equipment. The run was made in four hours and forty minutes, delayed time fifty-two minutes, so that the actual running time for the trip was three hours and forty-eight minutes. This is the shortest time made on any of the test runs. The total coal consumed for the trip was 9,390 pounds, giving an average of 37.6 pounds of coal per thousand ton miles. During the trip 64,989 pounds of water




were delivered to the boiler. The equivalent evaporation was 7.74 pounds of water per pound of coal. The theoretical evaporation of the coal burned for this trip as determined by analysis was 14 pounds of water per pound of coal, so that the efficiency of the boiler was 55.3 per cent. The ash in the coal as fired was 1,160 pounds, that removed from ashpan at the end of trip was 1,287 pounds. These figures show a close comparison with theoretical ash and actual ash.

*Run No. 5, Engine 923.*—The run was made on August 27th, with 1,265 tons in 69 cars. The total time on road was six hours and fourteen minutes. The delayed time twenty-nine minutes, so that the actual running time was five hours and forty-five minutes. This was the first run made on up grade with engine equipped with arch brick.

The total fuel consumed for the trip was 24,618 pounds of coal, or an average of 238.8 pounds of coal per thousand ton miles. This was the very best record obtained during the test with this engine on up-grade runs. On the heavy grade from Timpas to Simpson the average fuel consumption per thousand ton miles was 292.9 pounds of coal. During the trip 169,713 pounds of water were supplied to the boiler. The evaporation from and at 212 degrees was 7.82 pounds of water per pound of coal. The boiler efficiency was 52.2 per cent. On the portion of the run from Timpas to Simpson, the boiler efficiency was 56.3 per cent. The engine gave a drawbar pull of 34,220 pounds at a speed of 11.8 miles per hour, 27,650 pounds at a speed of 15.6 miles per hour, and 24,540 pounds drawbar pull at a speed of 19.6 miles per hour. All observations made during the test runs are shown on the accompanying chart.

*Run No. 6, Engine 923.*—This run from Trinidad to La Junta was made on August 28th with 3,101 tons in a train of sixty-five cars. The total time on road was seven hours and thirty-four minutes, total delayed time three hours and six minutes, so that the actual running time was four hours and twenty-nine minutes. The total fuel consumption for the trip was 11,635 pounds of coal, the average coal consumption for the run was 46.1 pounds per thousand ton miles. The water supplied to the boiler for the trip was 80,763 pounds. The evaporation was 6.94 pounds of water per pound of coal. The equivalent evaporation from and at 212 degrees was 7.87 pounds of water per pound of coal. This evaporation was considerably better than was made by engine on any other down grade run. The theoretical evaporation of the coal used for the trip was 13.8 pounds of water per pound of coal, so that the boiler efficiency for this trip was 57 per cent.

*Run No. 7, Engine 923.*—The run was made August 29th from La Junta to Trinidad with 1,176 tons in a train of sixty-four cars. The total time for the trip was six hours and fifteen minutes, the delayed time thirty-two minutes, so that the actual running time was five hours and forty-three minutes. The total coal consumed for the trip was 25,981 pounds, of which 11,968 pounds were used from Timpas to Simpson. The average fuel consumption per thousand ton miles for the entire trip was 271.2 pounds of coal, and for the run from Timpas to Simpson was 315.1 pounds of coal per thousand ton miles. The total water supplied to the boiler for the trip was 179,175 pounds, from Timpas to Simpson, 81,785 pounds. The equivalent evaporation for the trip was 7.89 pounds of water per pound of coal; from Timpas to Simpson, the equivalent evaporation was 7.87 per cent. The boiler efficiency for the trip was 56.1 per cent., and for that part of the run between Timpas and Simpson, the boiler efficiency was 57.4 per cent. At a speed of 17.3 miles per hour, a drawbar pull of 27,990 pounds was exerted; at 26 miles per hour a drawbar pull of 14,690 pounds was exerted. A maximum of 1,460 indicated horsepower was developed on this run at mile post 593; at the same time a drawbar horsepower of 1202 was

developed, so that 82.3 per cent. of the power developed in the cylinders was exerted in pulling the train. The resistance of engine and tender to motion, together with frictional resistance, amounted to 258 horsepower or 17.7 per cent. The speed at this time was 18.9 miles per hour. These results were obtained on a slight momentum grade; soon after this reading was taken the speed and power dropped off.

The average results of three runs with each locomotive (Nos. 10, 12, 14 on 901, and 3, 5, 7 on 923) are given in the table below.

| ENGINE NUMBER | 901 | 923 |
|---|---|---|
| Running time, hrs., min | 5-21 | 5-55 |
| Speed, M. P. H. | 15.7 | 13.8 |
| Train tonnage | 1,339 | 1,189 |
| Number of cars | 51 | 61 |
| Lbs. of coal per thousand ton miles | 211.9 | 275.7 |
| Total fuel fired, lbs. | 23,131 | 25,862 |
| Coal per hour, based on | | |
| Total time on road | 3,167 | 3,723 |
| Running time | 4,413 | 4,373 |
| Rate of combustion, coal per hour | | |
| Per sq. ft. grate area | 75.5 | 74.8 |
| Per sq. ft. heating surface | 1.23 | 1.01 |
| Draft, inches of water | | |
| Top of front end | 5.03 | 5.76 |
| Front of flue sheet | 3.53 | 4.20 |
| Side of firebox | 1.3 | 2.1 |
| Ash pan | .63 | .43 |
| Total water supply to boiler, lbs. | 166,919 | 173,932 |
| Steam per hour, lbs. | | |
| From boiler, moist | 31,790 | 29,413 |
| To cylinders | 30,844 | 28,344 |
| Per sq. ft. heating surface | 8.57 | 6.51 |
| Pressure, lbs. per sq. in. | | |
| Boiler | 189 | 202 |
| High pressure superheater | 182 | ..... |
| Low pressure superheater | 82.3 | ..... |
| Atmosphere | 13.47 | 13.49 |
| Quality of steam, per cent. | | |
| At dome | 98.9 | 98.9 |
| High pressure exhaust | 96.9 | ..... |
| Temperature of steam leaving | | |
| High pressure superheater | 403.3 | ..... |
| Low pressure superheater | 416.3 | ..... |
| Superheat, degs. Fahr. | | |
| Leaving H. P. superheater | 22.6 | ..... |
| Leaving L. P. superheater | 93.3 | ..... |
| Coal by analysis | | |
| Heating value, B. T. U. | 12,992 | 13,488 |
| Dry coal fired, lbs. | 23,142 | 25,863 |
| Combustible fired, lbs. | 20,124 | 22,729 |
| Ash fired | 3,082 | 3,138 |
| Lbs. per sq. ft. grate area per hour | | |
| Dry coal | 75.5 | 74.6 |
| Combustible | 65.7 | 66.7 |
| Ratio, total water to total coal | 7.17 | 6.70 |
| Equivalent evaporation from and at 212 degs. Fahr. | | |
| Per sq. ft. heating surface per hour | 10.23 | 7.81 |
| Per lb. of coal | 8.27 | 7.63 |
| Per lb. of combustible | 9.57 | 8.79 |
| Crediting heat to superheater | | |
| Per lb. of coal | 8.83 | ..... |
| Per lb. of combustible | 9.73 | ..... |
| Indicated horsepower | | |
| H. P. cylinders | 416 | 542 |
| L. P. cylinders | 846 | 643 |
| All cylinders | 1,262 | 1,185 |
| Draw bar pull, lbs. | 24,705 | 24,168 |
| Draw bar horsepower | 1,001 | 970 |
| Machine friction, horsepower | 261 | 214 |
| Machine efficiency, per cent | 79.3 | 81.9 |
| Locomotive efficiency | 4.5 | 4.2 |
| Boiler horsepower | 1,155 | 978 |
| Boiler efficiency, per cent | 65.9 | 53.5 |

CONCLUSIONS.

A study of the results lead H. B. MacFarland, engineer of tests, who was in charge, to draw the following conclusions:

1. There is a marked decrease in coal consumption for a superheater engine. The decrease averages 20.8 per cent. per thousand ton miles for up grade runs, 11.5 per cent. for down grade runs, and 19.6 per cent. for constant hard working of engine on heavy grades.

2. There is a reduction of total water for up grade and down grade runs, also for heavy grade work with superheater engine.

3. Superheater engine uses 10 per cent. less water per hour, developing more drawbar horsepower on heavy working.

4. Superheater engine shows for heavy working, a decrease of 16.3 per cent. in coal per indicated horsepower hour.

5. Superheater engine shows for heavy working a decrease of 12.9 per cent. in dry steam per indicated horse-power hour.

6. There is a reduction in coal of 14.1 per cent. per drawbar horsepower hour in favor of superheater engine.

7. Superheater engine shows a decrease in heat units per drawbar horsepower of 17.3 per cent.

8. There is a marked increase in evaporation of superheater engine. It gave an average of 11.6 per cent. more dry steam per pound of coal than non-superheater engine.

9. Superheater engine with 16.6 per cent. less heating surface gives equivalent evaporation of 10.6 per cent. more water per square foot heating surface than non-superheater engine.

10. Superheater engine shows a boiler efficiency 7.6 per cent. greater than non-superheater engine; with credit for heat to superheater from waste gases the boiler efficiency is 15.8 per cent. greater.

11. Boiler capacity is increased because of heat recovered in superheated steam by 7.1 per cent. Boiler requirements are further decreased on account of lower water rate of engine, due to superheated steam. The resulting effect of superheating as shown by the tests is to increase the effective boiler capacity without increasing its actual capacity.

12. No difficulty was experienced in working water in steam to high pressure cylinders, as the moisture was evaporated in the superheater under all conditions. On this account the superheater engine is not liable to knock out cylinder head, or in case of compound engines to loosen the intermediate joint between high and low pressure cylinders.

13. Steam from low pressure superheater was superheated 90 to 125 degrees and supplied to cylinders at not over 450 degrees.

14. Superheat was sufficient to prevent entirely the dripping of water from cylinder cocks.

15. There was great uniformity of superheat under varying loads and rates of fuel consumption.

16. The tests show that for operation under local condition with usual side track delays that a superheater engine gives greater economy than a non-superheater engine.

17. The efficiency of the low pressure superheater is greater than that of the high pressure superheater. On this account superheating low pressure steam is more desirable than superheating high pressure steam.

18. The brick arch in the firebox gave an increase in economy of operation by decreasing the coal per thousand ton miles and by increasing the evaporation per pound of coal.

19. Superheater engine developed 20 per cent. more drawbar horsepower per square foot of heating surface than non-superheater engine.

20. Superheater engine gave for best performance ten per cent. more horsepower for same cylinder volumes than non-superheater engine.

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HEATING AFTER CASE HARDENING.—We have introduced one new feature, and that is reheating the work after it has gone through the old method of case hardening. In reheating, we simply place the work in an open furnace, leaving it there sufficiently long to get a uniform and even heat. Heat up to 1,500 deg. Fahr. and cool in running water. This will add a higher percentage of hardness, and also restore all inequalities in the structure of the material. If your first case hardening has been overheated, causing the material to become brittle, careful reheating will restore or place the material in proper condition. I have often noticed case hardened material look crystalline all the way through on small articles, and be as brash or brittle as overheated and hardened tool steel. I have taken some of these same articles, properly reheated them, broken them and found the dark or gray iron fiber that was missing in the first hardening. The success of good case hardening is to harden to the desired depth, and retain in a great measure a tough and fibrous interior. This can be accomplished by reheating.—*George F. Hinkens of the Westinghouse Air Brake Company before the International Railroad Master Blacksmiths' Assn.*

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SUCCESSFUL INDUSTRIAL EDUCATION.—In the broader view of solving this problem of industrial education there seems to be just one way of doing it, and that is to take the school to the boy or girl who is on the job. Statistics prove that after they have been educated in trade schools the majority do not follow the trade for which they have been prepared. The one thing we are pleading for is a combination of the school and the shop. It seems to us after a trial both of the university end and the public school end, that is the only feasible scheme.—*Prof. Schneider at the General Foremen's Convention.*

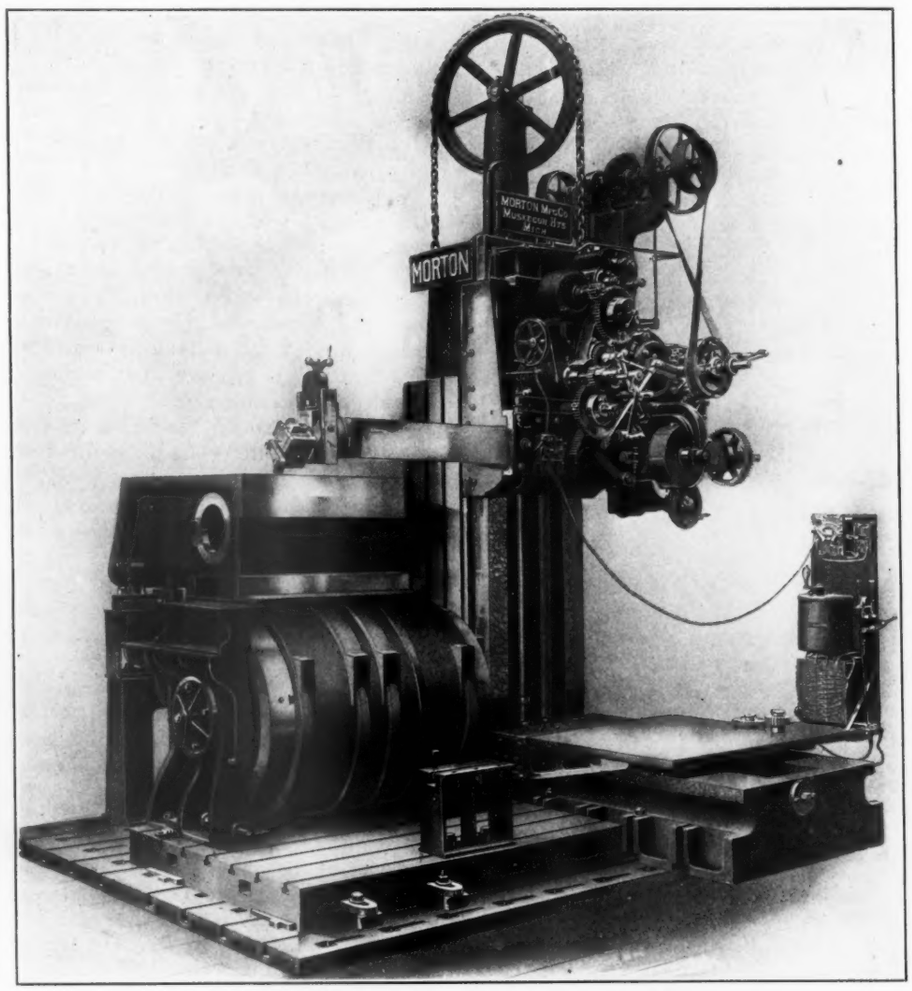
## TWO NEW TOOLS FOR RAILROAD SHOPS.

MORTON MANUFACTURING CO.

After a careful study of the general requirements of the modern railroad shop these two unique and useful tools have been designed by the manufacturers. They are unique by reason of the number of operations which they perform successfully and accurately and they have proven to be machines of unequalled capacity and advantage.

### TRAVELING HEAD LOCOMOTIVE CYLINDER PLANER.

One of the most remarkable tools of its kind yet produced in this country is the new traveling head cylinder planer shown in the accompanying illustrations. It has been designed with a view to save a large amount of power and also time and labor by performing nearly all the different operations in machining cylinder castings of any size with one setting. This includes planing the sides of the casting and the valve seat, and milling the steam ports as well as boring the valve chamber in a piston valve casting.




MORTON TRAVELING HEAD PLANER FOR LOCOMOTIVE CYLINDERS.

Large bearing surfaces and square rail bearings are provided in the bed, giving a very rigid construction. The casting is heavily cross ribbed and open slots are provided on either side for securing to the floor plate, enabling the bolts to be easily removed when used as a portable machine. The column and its saddle are made in one piece, heavily constructed throughout, the T slot plate on the front column presenting a surface against which a suitable bearing may be bolted for supporting high work, thereby drawing the thrust of the cut directly against the column. The vertically moving apron is closely fitted to the column and provided with means to compensate for wear. This apron carries the feeding, cutting and other working mechanism of the machine. It has ample bearing surface to make it operate easily. The saddle casting is extended in such a manner that in connecting with the taper gibs, which are provided, it forms a bearing that insures exceptional rigidity.

Steel is used in the construction of the ram, which is made square and hollow, having a bearing on all four sides extending through the entire length of the apron. Power is applied to the ram by rack teeth being cut on the back side and having a bronze strip inserted to give a continuous bearing. The head also is made entirely of steel and screws into the end of the ram. It is graduated for planing angles and is universally adjusted, being held in position by friction.

In the design a compound, disc friction feed is used, the disc being lined on either side with vulcanized fiber. It is of the automatic relieving type and provided with instantaneous quick change. This feed can be made at either end of the valve, or at both ends where the full feed is required.

The driving power is obtained with a 10 horsepower variable speed electric motor direct attached to the base of the column, the power being transmitted through gears to a vertical spline shaft transmitting power to the attached counter shaft, which in turn carries power through belts to the friction clutch pulley, controlling the reciprocating motion. By means of the special, improved friction clutches the reversing motion is accomplished without shock or jar. A clutch is provided so that the counter shaft may be stopped and started independently of the motor, the gears being all encased and run in oil. This is a good feature as the counter shaft can be reversed for back facing and boring when necessary. This machine may be driven with a belt

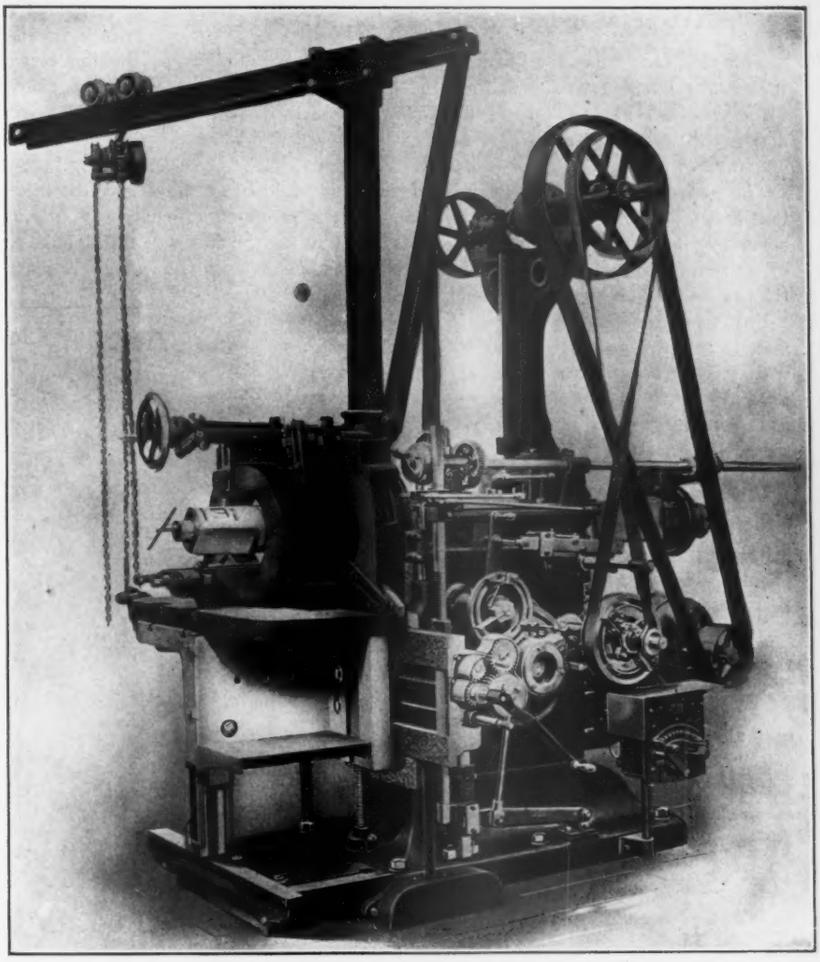
through an ordinary countershaft when desired, but the motor drive is more convenient for a tool of this type, and is recommended.

The counterbalance for the vertically moving apron consists of an air cylinder on the rear side of the column, to which a compressor is applied and regulated automatically when the pressure comes to a given point. This compressor is driven directly by a small motor, making it independent of any outside connection.

The column is fitted with an anti-friction device operating on a steel track and so arranged that a certain portion of the weight of the column, apron, and other mechanism, is carried, leaving only enough weight on the bearing to insure the machine working steadily. Coil springs are also provided, so that the tension may be adjusted to operate with the least power.

The great advantage of the cylinder chucks located on the bed plate is very evident and large castings may be rotated by this means, permitting the planing of all sides. The bed plate can be turned about on the floor plate, so that only one setting of the work is necessary after the cylinders have been bored. The chucks are of the three-jaw universal type and expand in the counter bore of the cylinder, a bolt passing through so that all surfaces are firmly secured and held in position while in operation.

With the same setting the milling of the ports is also accomplished, the port milling attachment being quickly applied to the square section of the ram without removing the shaper head. It is provided with a vertical arbor and a train of gearing, which gives it ample power. The power is applied to the spline shaft connecting with the main rotary driving mechanism for driving the internal arbor, being provided with automatic feed.



NEW 36-IN. DRAW CUT SHAPER FOR MACHINING DRIVER BOXES.

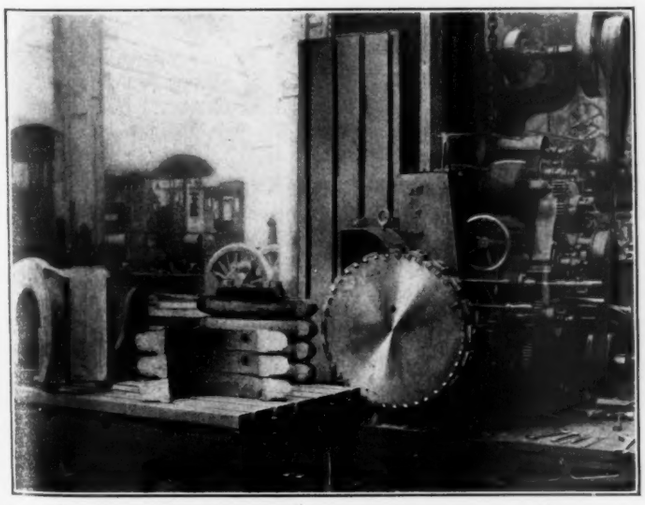
Another important feature of this machine is the milling and boring attachment, which is provided with a hollow steel arbor passing through the ram and journaled in bronze bearings of large dimensions. The front bearing is tapered and made adjustable to compensate for wear. A specially divided steel yoke is secured to the back end of the ram, which carries the journals and gearing, the main driving gears being steel. This yoke is designed so that it caps over the square section of the ram, eliminating all danger of moving. By removing three bolts the entire cap and gearing may be removed with the yoke, thus making a very quick change. The arbor has a retaining or drawing-in bolt which passes through its entire length and is provided with a forcing nut at the rear end, so that tools may be engaged or disengaged.

The feed for milling and boring consists of a special feed box secured to the vertically moving saddle and is provided with ten changes suitable for either boring or milling. Power is applied by flexible shafts and gears in the speed change box. Provision is made for reversing so that the saddle may be fed vertically in either direction, the column horizontally and the ram in or out, all these feeds being operated by means of one lever.

A table 36 in. by 8 ft. by 30 in. is provided for small work with the upper surface T slotted and provided with open slots on the lower surface. It can be used in conjunction with either the shaper or planer movements and is also of great service for work when using the rotary planing outfit, as shown in the small view. This rotary planing attachment is quickly placed in position and with it the sides of trailer boxes, eccentric straps and a great variety of other work may be machined.

The floor plate furnished with this equipment is made in two sections, each 4½ ft. wide by 13 ft. long, and is especially designed for rigidity and strength. All gears throughout the machine subjected to heavy strain are made either of bronze or steel. Below are given some of the principal dimensions of this machine:

| | |
|---|---|
| Stroke | 48 in. |
| Longitudinal feed | 9 ft. |
| Vertical feed | 60 in. |
| Feed in tool head | 8 in. |
| Rev. of boring arbor per min., from | 3½ to 42 |
| Floor space required | 14 by 16 ft. |
| Diameter of cylinder chucks | 28 in. |



MORTON TRAVELING HEAD PLANER WITH ROTARY PLANING ATTACHMENT.

## SPECIAL 32-INCH DRAW CUT RAILROAD SHAPER.

This new shaper is very heavy, powerful and accurate, making it specially adapted to railroad work. In fact, it was designed after years of experience designing tools used in railroad shops and particularly with a good rate of cutting speed and a heavy cut in view.

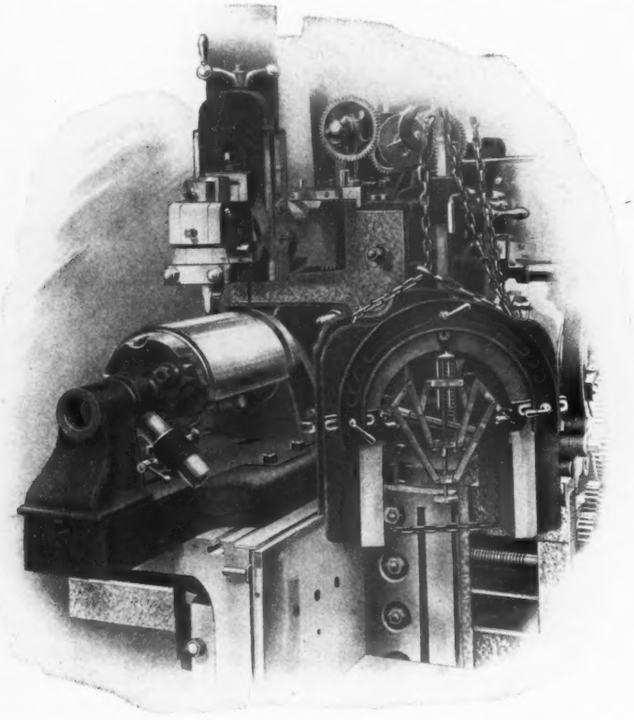
The general view shows the usual heavy and rigid construction and good design of the Morton shaper. It is provided with a rotating arbor for planing curved surfaces such as the inside of a driving box, with a rotary feed deriving its power from the regular friction through a gear and ratchet.

Box type construction is used in the column, making it very strong, and the saddle is fitted with large square rail bearings, with gibs to compensate for wear on the cross rail. It is also provided with T slots as shown. There is a small table of a special design of the angular bracket type, presenting a working surface on the top side and having a T slotted side, to which work may be secured.

The reciprocating motion of the ram is obtained by open and cross belts on either side of the machine, and instead of shifting belts, friction clutches similar to those on the large cylinder planer described above are employed. The length of stroke may be adjusted while the machine is in motion, and it can be reversed quickly at any point of the stroke by a small lever.

There is a power traverse for raising and lowering the cross rail and moving the apron or saddle horizontally for adjustment of the work, which is easily and quickly thrown in or out so that all cranking is practically eliminated. A swivel base type vise with double screws is provided and so constructed that the tendency of the work to raise on the parallel strips is largely overcome.

The main driving pinion is made from a steel forging with cut teeth of liberal proportions. It runs in oil, insuring perfect operation and minimum of wear. All the shafting is made of high grade steel and ground to size. A special sliding table is fitted to the back of the machine for the electric drive and the



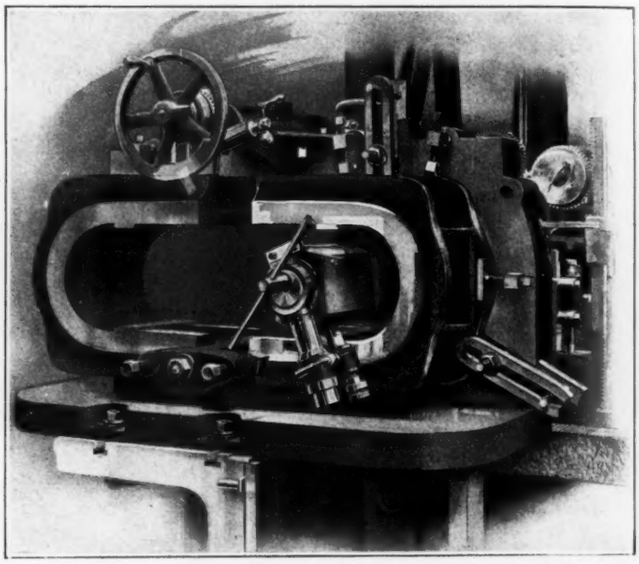
32-IN. DRAW CUT SHAPER WITH DRIVING BOX SHELL PLANING ATTACHMENT—SHOWING TEMPLATE TOOLS ON SUSPENDED BOX.

counter shaft supplied with a special friction clutch is secured to the top of the machine, so that it is not necessary to stop the motor in order to stop the machine.

A mast and trolley, as in previous designs, are built on the machine, and either a chain or air hoist can be furnished.

A special feature is the driving box shell planing attachment, which consists of the rotating chuck, as shown in one of the smaller views, and also the micrometer with scriber at the front of the chuck. The rotary feed is transmitted to the chuck through a worm gear and flexible shaft connecting with the ordinary feed mechanism. The small view shows also a suspended driving box with the template tool attached just before transferring the measurements to the shell.

The driving box slotting equipment is also very unique with the double chuck as shown in another illustration. The rotary head is used with this arrangement with an outer bearing to



32-IN. DRAW CUT SHAPER SHOWING MICROMETER ATTACHMENT.

receive the micrometer, while a line is scribed on the face of the box.

The shaper is also provided with a rod brass planing attachment designed for planing the sides and strap fit of brasses of all sizes. The various attachments make this machine very unique in that it will meet fully all railroad shop requirements, including economical and accurate work.

It is claimed that the shell or brass will have a better and more perfect bearing in the driving box because the lines of cut on both parts are parallel, eliminating the trouble of loose brasses. And the lines of cut on the journal surface of the brass will come to a good running bearing on the axle more quickly by having them parallel with the axle and running crosswise with its lines than by using the old method of machining in a lathe or on a boring mill.

Both the cylinder planer and the draw cut railroad shaper are made by the Morton Mfg. Co., Muskegon Heights, Mich.

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PIECEWORK.—There is no system like piecework with the class of men we are getting to-day. You get up here and say you have 200 machinists. What do you do with them? You are spending a lot of money in looking after those machinists, but when you put the men on piecework you do not have to do so. We have an assistant general foreman who times all new operations. The men get so that the minute they get hold of a new job they look him up and say: "Come and time the new job that I have." We have never cut the price in Cleveland with the exception of where the company has spent money in buying new tools. We endeavor to be fair to the men and fair to the company. We do not work piecework on a job until the piecework schedule has been signed by five men—the assistant general foreman, the general foreman, the master mechanic, the shop specialist, and the mechanical superintendent. And the price cannot be changed without the consent of the five people that signed the cards. I do not know of a place where the price has been cut for three years.—*J. A. Boyden at the General Foremen's Convention.*

## NEW ELECTRIC LOCOMOTIVE FOR THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD.

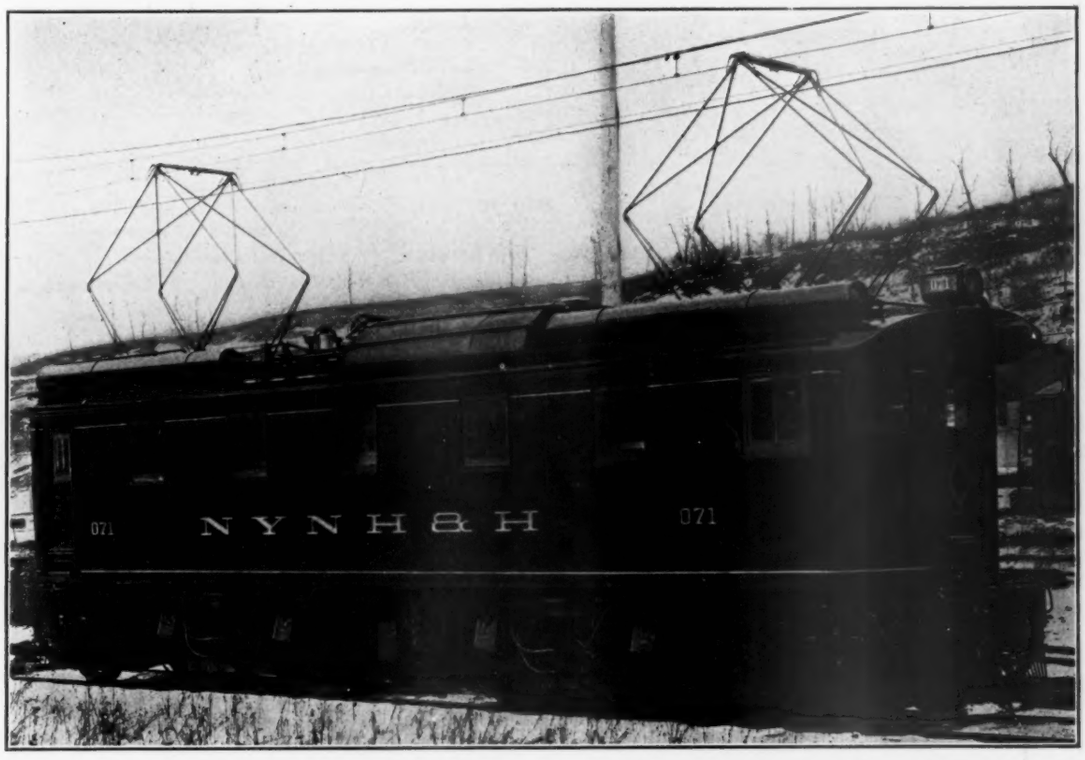
An electric locomotive of about twice the capacity of those now in use * has recently been completed by the Westinghouse Electric and Manufacturing Co. and the Baldwin Locomotive Works for the electrified section of the New Haven between New York and Stamford. This locomotive differs in many respects from the present design and was built to fill the following specifications:

To be able to haul a 1,500-ton freight train at a speed of 35 miles an hour on level track, where the train resistance is not over six pounds per ton. To be capable of hauling an 800-ton passenger train at a speed of 45 miles an hour. This capacity would enable it to haul an 800-ton limited train from the Grand Central Station, New York City, to New Haven, a distance of 73 miles with no intermediate stops, in one hour and fifty-five minutes; or to haul an 800-ton express train the same distance in two hours and twelve minutes, with an allowance of five minutes for stops; or to haul a 350-ton local train in two hours and forty-five minutes, with an average stop of forty-five seconds.

That the locomotive is an unqualified success has been demonstrated by frequent tests made under severe operating conditions, which have shown that it has a good margin over the specifications.

The design of the trucks and running gear is unique. The truck frames are connected by an intermediate draw-bar. One truck has only a rotative motion about its center-pin, while the other has a fore-and-aft, as well as a rotative motion, in order to compensate for the angular positions of the trucks and draw-bar when the locomotive is traversing a curve. The tractive force is transmitted through the truck frames and draw-bar instead of through the main frame. Each truck has two pairs of driving wheels, and a single pair of leading wheels. The wheel loads are equalized as in steam locomotive practice. To assist in reducing shocks and keeping the two trucks in alignment, chafing castings and spring buffers are interposed between the truck frames, under the center of the locomotive. The weight of the cab, instead of being carried on the center-pin, is carried on friction plates at the ends of the truck. The weight is applied through springs, which have a considerable latitude for motion to allow for variation in the track without changing materially the distribution of weight on the ends of the truck. The plan of running-gear and cab support adopted for this locomotive prevents any periodic vibration or "nosing," minimizes shocks on the truck and roadbed and insures easy riding. As the rigid wheel base is only seven feet for each truck, the locomotive is extremely flexible, and easy on the track at curves and special work.

The electrical equipment comprises four single-phase geared motors, together with the auxiliary apparatus necessary for their operation from the 11,000-volt, alternating-current or 600-volt, direct-current circuits of the electrified sections of the New Haven and the New York Central railroads respectively. The motors are of the same general electrical design as those in use on the present New Haven locomotives, the main differences being in the mechanical details and general arrangement.



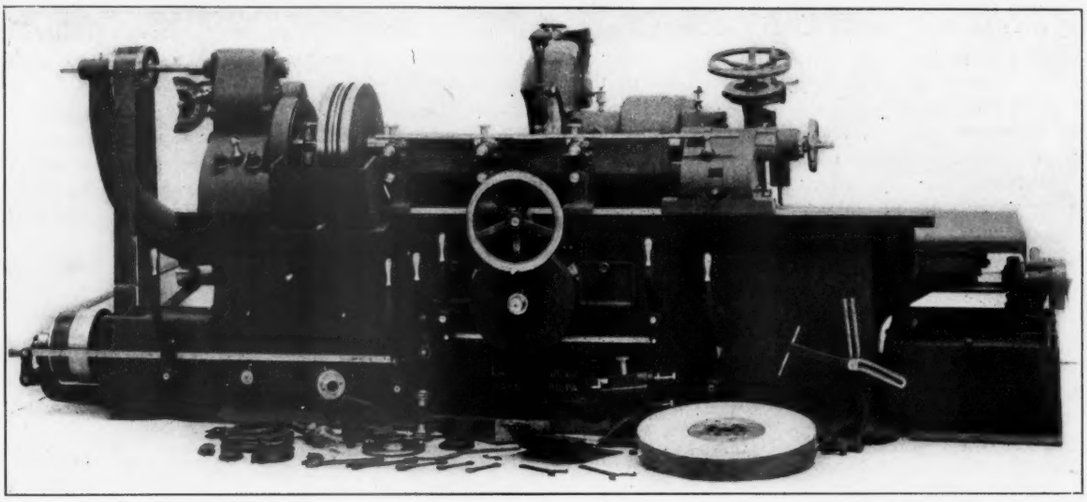

POWERFUL ELECTRIC LOCOMOTIVE FOR THE NEW YORK, NEW HAVEN AND HARTFORD R. R.

Each motor is rigidly mounted on the truck frame and directly above a quill surrounding the driving axle, to which it is geared. The motors project into the cab, and the floor above them is raised. This method of mounting the motors on the truck frame gives a high center of gravity, and prevents the transmission of strains and shocks from the track and roadbed to the motors.

An air blast transformer is provided for lowering the trolley line voltage to that required by the motors. The control apparatus is of the Westinghouse electro-pneumatic type.

When operating on alternating current, all four motors are connected in multiple, and the control is obtained by changing the connections to various voltage taps on the main transformer. On direct current the motors are first grouped all in series, and then two in series and two in parallel, in combination with various resistance steps. Provision is made for cutting out any one of the four motors singly on either alternating current or direct current. A master controller and brake valve are located in each end of the cab so that the locomotives can be operated from either end, and the system of control is such that two or more locomotives can be coupled together and operated from one master controller.

* See AMERICAN ENGINEER, October, 1907, p. 396.



LANDIS 16″ x 72″ HEAVY DUTY GAP GRINDING MACHINE.

## 16 X 72 INCH HEAVY DUTY SELF CONTAINED GRINDING MACHINE, WITH GAP.

The accompanying illustrations show a new grinding machine designed on original lines and built by the Landis Tool Co., of Waynesboro, Pa.

Throughout the entire machine it is of high power and heavy duty construction, and is specially adapted for railroad shop work, such as grinding locomotive pistons, piston valves, valve stems, crank, link, and knuckle pins, axles, etc. It is provided with a gap, as shown, so that pistons can be ground with their heads in place and also for the swing of valve yokes when grinding the stems. The gap can be located along the table to suit the work when the machine is built. The machine is of the self-contained type and is designed to be driven either by a motor or from the line shaft.

One of the views shows the arrangement of the electric drive. With either form of drive the power is applied to the main shaft at the rear of the machine, from which it is distributed and transmitted to all of the different working parts. The grinding wheel is driven from the large pulley seen in the end view, located at about the center of the machine, and mounted in a carriage rolling on the track shown extending from the base of the machine. It travels with the wheel carriage as it is traversed.

This pulley is driven by step grooves on the main shaft engaging rollers in its sleeve or hub, which makes practically a frictionless drive, as it is traversed or slides over the shaft.

The grinding wheel belt is 6 inches wide and passes over intermediate pulleys so arranged to automatically take up any change in its length and at the same time keep it under a uniform tension.

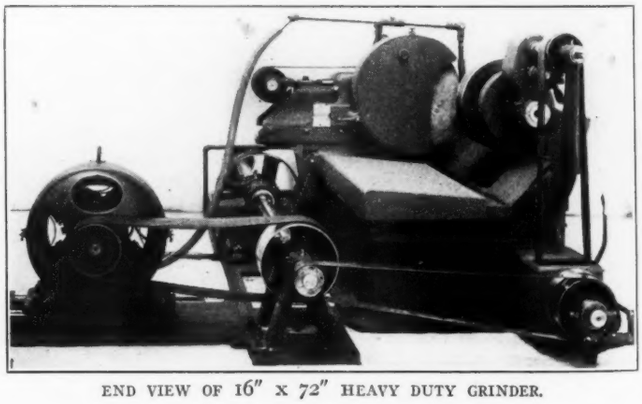
This belt has almost 200 degrees contact on both the driving and driven pulleys and its length can change about 8 inches by stretching before necessary to remove a section and shorten.

A feature that is very essential for rapid and perfect grinding is a massive and rigid grinding wheel head, such as found on this machine. The spindle of ample dimensions is made of hardened steel; the bearings are of phosphor bronze, self-aligning, and adjusted in tapers for taking up wear. They have self-oilers. The grinding wheel has provision for balancing, this being done by two weights mounted to be adjusted in a circular or annular groove in the side of the wheel collar or center.

A very powerfully geared headstock that has ample power for driving the largest piece of work that can be placed in the machine has been provided. It is arranged to give five changes of speed to the work, these being made mechanically by the movement of a single lever and by shifting a back gear in the gear box at the end of the machine another range of five speeds is obtained, making a total of ten working speeds. These speeds are indicated on a dial, shown on front view, and the changes can be made quickly and with ease. All parts of the clutch mechanism are made of hardened tool steel and all gears are finished by planing.

The work revolving and traversing mechanism are driven from the gear box at the end to which power is delivered by the belt from the main shaft. The work and traverse drives of the wheel are started and stopped together by a clutch in the pulley on the end of the gear box, operated by a lever at the front of the machine. These drives can also be operated separately and their speeds are varied independent of each other. The pump is driven from the end of the main shaft, as shown at the right of the front view.

It was suggested in an article in the April, 1909, number of this journal how the railroads could add considerably to the life of such parts as car axles, piston rods, valve stems, crank pins, etc., by grinding after they have become worn instead of turning them on a lathe. In addition to this advantage it has been demonstrated in recent railroad practice that there is a decided saving of time. For this reason the new machine is especially interesting to the railroads, leaving entirely out of consideration the superior wearing qualities of a ground surface and the consequent saving of packing and brasses.



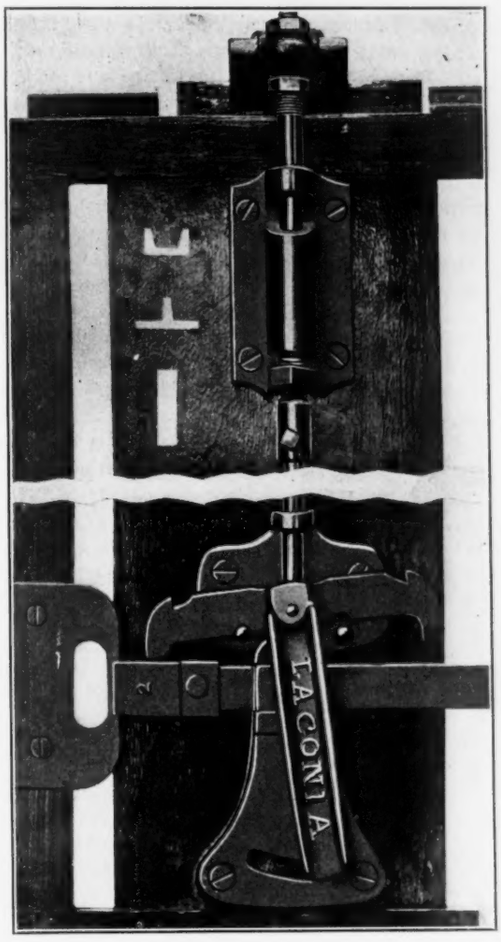
END VIEW OF 16″ x 72″ HEAVY DUTY GRINDER.

Following are some actual performances with this machine: A piston rod 3½ in. by 36 in. which was worn in service was ground accurately in 15 minutes without any previous turning on a lathe. The stock removed was 1-32 in. diameter. The stock removed from a valve stem 1¼ in. by 18 in. was 1-32 in. diam. in 6 minutes, and a connecting rod pin 4⅜ in. by 8⅝ in. was ground down about 1-32 in. diam. in 9 minutes. These results are examples of what can be accomplished and show the possibilities of grinding machines in railroad work.

It is announced that there will be demonstrations on these grinding machines at the master mechanics' and master car builders' convention.

## SLIDING DOOR FASTENERS.

Damage to baggage or express matter, as well as injury to employees due to the sudden opening or closing of sliding doors when the brakes are quickly applied or released, is common enough to require some preventative. Recognizing this condition, W. H. Durant, air brake inspector of the Boston & Maine Railroad, has designed a spring fastener that will hold the door at any desired point and at the same time permit it to be easily



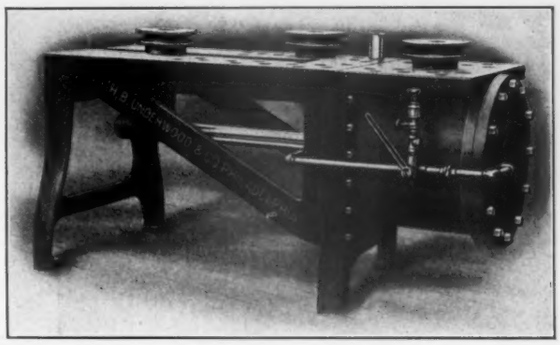

and freely opened or closed when desired. This lock is arranged to grip the track on which the door slides and is held in operation by a spring in the guide casting at the top of the door. The operating handle is located at a convenient height and swings either way. As it is pulled to one side it moves about one of the fulcrums and lifts the rod against the resistance of the spring and releases the friction at the top of the track. At the same time a wedge shape projection on the handle arm unlatches the catch that snaps into the catch plate on the jamb. When it is desired to lock the door on the inside the handle is simply locked to the catch bar. This fastener is made for both right and left handed doors and is being handled by Irving S. Elliott, Lakeport, N. H.

## A NEW PIPE BENDER.

A pipe bender operated by either steam or compressed air, as desired, which has a cylinder 20 in. in diameter and is limited in power only by the pressure of the working agent, is shown in the accompanying illustration. This bender has a large table that is entirely unobstructed, the ram being underneath the table and sliding in a strongly constructed guide. The ram carries a pin extending above the table surface on which a roller of suitable size can be placed. The table is provided with numerous holes in which pins or rollers of various sizes can be placed and permit the bending of practically any desired shape.

This bender can be used to some extent as a bulldozer if desired by simply placing the dies on the ram projection and the table. Because of its power, considerable work of this character can be satisfactorily performed.

A special feature of this device is the delicate movement which can be obtained by an arrangement that provides pressure on both sides of the piston at all times. The operating valve is so constructed that only the amount of air or steam required for the actual bending is wasted; the air is transferred from one side of the piston to the other and the piston is forced forward because of the larger area on that side due to the absence of the piston rod. This feature permits the piston being moved only



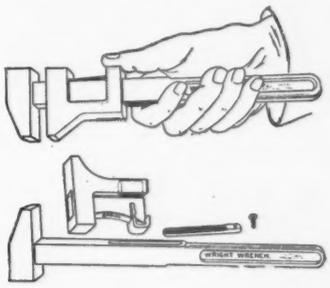
a fraction of an inch when desired, and it may be held perfectly stationary to allow for measuring or for placing templets on the work. Nicety of control of this character is very desirable, particularly for straightening work.

This machine is manufactured by H. B. Underwood & Co., Philadelphia, Pa.

## A NEW ADJUSTABLE WRENCH.

A new wrench of novel construction has recently been placed upon the market by the Wright Wrench and Forging Co., Canton, O., and will be demonstrated at the coming Master Mechanics' and Master Car Builders' conventions. It will be seen, by referring to the illustration, that it consists of a combined upper jaw and handle, a lower or sliding jaw, an adjustment spring and a steel rack set into the lower face of the handle. By taking the wrench as shown in the illustration a slight pressure of the thumb will depress the movable jaw against the resistance of the spring and release its engagement with the rack. It can then be opened or closed as desired, when the release of the pressure causes it to again engage the rack.

On all wrenches up to 12 in. the adjustment is within .04 of an

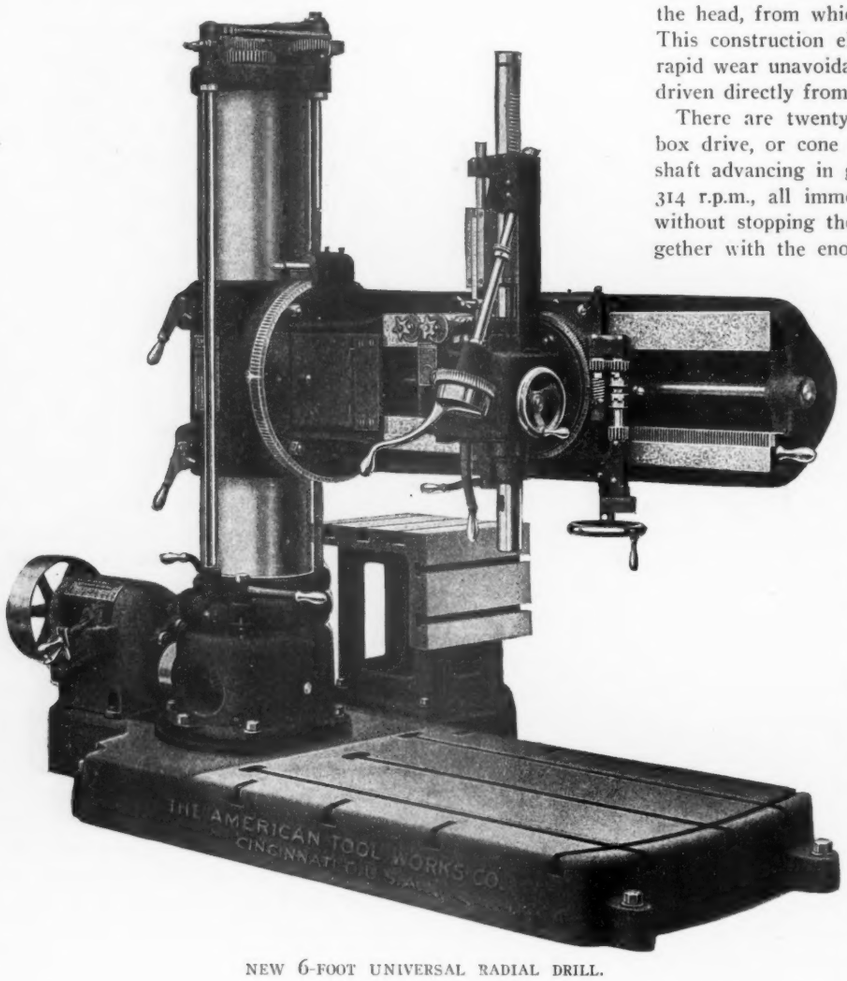



inch and on the 15 in. and 18 in. sizes within 1/16 of an inch. The wrench is substantially built of carbonized steel, and is ground and polished. It is claimed that these wrenches have no back lash, and that they will not under any circumstances become locked on a nut. They are very quickly adjusted and can be used in either hand.

## NEW FULL UNIVERSAL TRIPLE GEARED RADIAL DRILL.

The universal radial drill has heretofore proven entirely inadequate to the severe duty imposed upon the modern plain arm radial, but its field of usefulness in machine shops is so large that a redesign was imperative. Up to the present time the universal radial has been incapable of driving to the limit high speed steel drills, principally because of lack of power and springing of the arm. The new machine shown in the accompanying view represents a radical departure in design and the highest development in this type of drill, which fulfills all the requirements in power and rigidity. It shows the result of careful consideration and in its design there are incorporated the many excellent features of the plain radial.

Every weakness heretofore encountered has been eliminated in the design of the arm of this universal drill. It is made in the form of upper and lower tube sections, bound together in the back by a double wall of metal and further reinforced by transverse ribbing. On the front wall ways are formed for carrying the unusually wide and rigid saddle, which is firmly locked at any point along the arm by means of a powerful clamping device. The arm is also clamped to the column by two small levers, which obviates loose wrenches. It is raised and lowered rapidly by a double thread, coarse pitch screw hung on ball bearings and controlled by a convenient lever which cannot be operated until slightly raised from its bearing, thus guarding against accident due to unintentional movement while the arm is clamped to the column. The arm is rotated in a complete circle by means of a worm engaging wheel cut in the periphery of the arm flange. This movement, in connection with the swiveling head, permits drilling and tapping at any angle radiating from the center of a sphere and is firmly clamped, as set, by four large binder bolts.




NEW 6-FOOT UNIVERSAL RADIAL DRILL.

Powerful steel triple gears are used in the head, making the design very compact. It may be swiveled through a complete circle by means of a hand wheel and worm, which feature is of special value in setting the spindle for angular drilling. The worm holds the head in any position and eliminates all possibility of accident through the head swinging around of its own weight when the clamping bolts are loosened. The hand wheel also affords quicker motion than the use of a wrench. The head is moved rapidly along the arm by means of multiple gearing and rack, through the same hand wheel which operates the head, by simply engaging the clutch shown in the illustration. A feature of great merit is found in the power transmitting elements between the arm shaft and the spindle. The saddle shaft, which forms part of this connection, is offset to one side of the spindle and mounted in two long bearings, one of which is integral with the saddle and the other with the swiveling head. Power is transmitted from the saddle shaft through mitre gears to a shaft in the head, from which the spindle is driven through spur gears. This construction eliminates the consequent loss of power and rapid wear unavoidable in a universal drill, where the spindle is driven directly from the arm shaft.

There are twenty-four changes of spindle speed with speed box drive, or cone pulley drive, with a double friction counter shaft advancing in geometrical progression, ranging from 19 to 314 r.p.m., all immediately available, by means of two levers, without stopping the machine. This wide range of speeds, together with the enormous power and rigidity, render this drill equally efficient when using either the ordinary carbon or high speed twist drills and particularly fits it for a wide range of tapping requirements.

The feeding mechanism, located on the head, provides eight rates of positive geared feed, covering a range in geometrical progression from .006 in. to .060 in. per revolution of the spindle. This mechanism is controlled by two dials, with the respective feeds indicated on the face. The rate of feed being used is plainly indicated at all times and reference to the index plates is unnecessary.

The drill is provided with a depth gauge and automatic trip of greatly improved and simplified design, which will trip a spindle at any predetermined depth. The tripping mechanism is so arranged that the spindle will be tripped at any point within the limit of travel by merely setting the trip dog so that the scale reads the depth to be drilled.

Another very good feature is the tapping mechanism, which is mounted on the girdle portion of the arm between the triple gears and the speed box. This construction has a distinct advantage over the usual design of universal drills where the tapping attachment is incorporated in the saddle mechanism, as it permits the use of more liberal proportions in the design of the reversing frictions than is otherwise possible. The frictions in the tapping attachment of this machine are of the double band type consisting of an internal expanding and an external contracting friction all in one. There is perhaps no one feature in the machine which is more responsible for the enormous pulling power than this double band friction, since the power of a radial drill is not dependent upon the size of the gearing and mechanism, but rests entirely with the capacity of the frictions, and the power that can be transmitted to the twist drill is only equal to the slipping point of the friction. It is claimed that the 6 ft. size of this machine will pull an 8 in. pipe tap.

The column is of the double tubular type, the sleeve or outer column revolving on conical roller bearings which are hardened and ground. It may be clamped in any position by means of a V clamping ring. This construction is practically equivalent to a double column and affords very exceptional rigidity.

A motor drive may be attached either by a direct connection or by means of gears or belting, using a motor of any type; however a motor on the base connected by a gear to the speed box would be the most simple and efficient method.

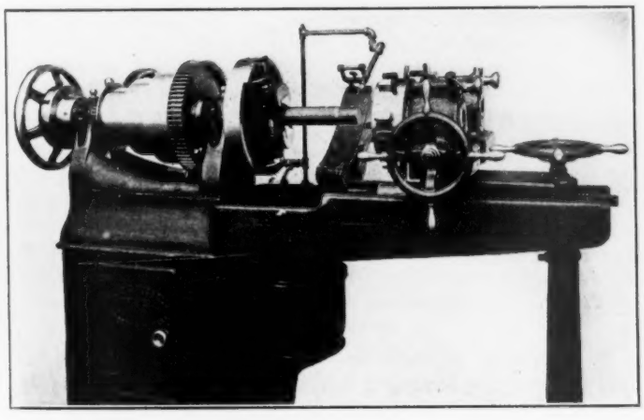
This machine is an entirely new development in the field of radial drills, being exceptionally rigid and powerful, accurate in its alignment, and at the same time arranged to be operated with the greatest ease. It is built by the American Tool Works Co., of Cincinnati, Ohio, in 4, 5, 6 and 7 ft. arm sizes.

## COMBINED BOLT CUTTER, NUT TAPPER, PIPE THREADER AND CUTTING-OFF MACHINE.

### ESPECIALLY ADAPTED FOR ROUNDHOUSE AND ERECTING SHOP PURPOSES.

Recently, in the presence of a representative of this journal, the bolt cutter shown in the accompanying illustrations threaded ten bolts of the following sizes: ¼, 5/16, ⅜, 7/16, ½, 9/16, ⅝, ¾, ⅞ and 1 in. in ten minutes. The same machine ran a thread 6½ in. long on a 1-in. bolt, taking but one minute from the time the workman picked up the stock until the finished bolt was removed from the machine. It also cut a thread on steel pipe of the following sizes: ¼, ⅜, ½, ¾, 1, 1¼, 1½ and 2 in. in fifteen minutes, taking but a little over one minute to replace the die heads for cutting bolts with those for pipe threading. Ten 1-in. bolts were threaded for a distance of 1⅞ in. in six minutes and 30 seconds.

In performing this work the machine was not operated by an expert and was set up temporarily on the shop floor, no special arrangements being made to obtain remarkably high speeds, and the secret of the excellent performance made lies in the design and construction of the machine itself, particularly in the arrangement of the dies on two circular heads, so constructed as to make it possible to obtain practically any size from one-quarter inch to one inch almost instantly without any adjustment or maneuvering. On another pair of heads, that can be substituted in less than a minute, dies for larger bolts or for pipe can be obtained.



GREEN RIVER BOLT AND PIPE CUTTER.

The machine consists of a head stock with a three step cone pulley and fitted with back gears, which drives a special design of chuck that is rapid in operation and positive in its grip. The arrangement of this chuck is shown in one of the illustrations. The spindle is made hollow so that any length of pipe or bolt can be cut. On the bed is a carriage operated by means of a rack and wheel, which carries the frames for the die heads, these being connected to a double threaded shaft, are rapidly opened or closed by means of a hand wheel in the front of the machine. Each of the die heads is accurately fitted into its support and is held in place by a set screw working in a V-shaped slot, which when tightened draws it to a secure bearing against the face of the carriers. A spring pin drops into an opening and prevents the die heads from turning when the dies are in their proper position. By loosening up the set screw and pulling back the pin the heads can be revolved and bring any size die desired quickly into working position. The heads are marked at the top with the size die which is in position for cutting.

Each pair of dies has independent stop pins controlling its cut. These can be shortened or lengthened as desired to give the proper diameter of thread. One of the illustrations shows a pair of the dies removed from the cutter head. They are made of

CHUCK FOR BOLT AND PIPE CUTTER.

the very best steel and are most carefully fitted into the circular heads, being held in place by three screws, one of which engages in spot hole on the die, the other two acting as clamps. The dies are made in pairs, each being properly marked and it is a very simple matter to replace them.

The machine is provided with a centrifugal oil pump, the lubricant draining through a screen into a tank below the bed of the machine, from which it is again pumped to the cutters.

A cutting off device is applied which can be swung back out of the way when not in use. This consists of a small carriage with a tool post and a hand operated cross feed.

In using this machine for nut tapping it is only necessary to clamp a tap in the chuck and place the nut in the jaws provided between the carriers that support the die heads and run the carriage up the same as when threading a bolt. It is not necessary to remove the die heads in order to tap a nut.

For roundhouse work this machine offers many advantages. It is also well suited for work in connection with the erecting shop, where it may be desired to quickly thread bolts or to chase a thread that has been damaged. With three sets of heads a machine is provided which will thread all practical size bolts from one-quarter to 2 in. as well as piping between the same sizes. The machine is rugged and will stand hard usage and where odd or various sized threading is to be done it will prove an excellent investment.

It is manufactured by The Wiley & Russell Mfg. Co., Greenfield, Mass.

JAMES R. PATERSON died of pneumonia at his residence, 191 North Avenue, Cranford, N. J., on May 31. Mr. Paterson, or "Pat" as he was so familiarly known among his friends, entered the service of the Angus Sinclair Co. in 1895, but recently severed his connection with that company to accept a position with the Commercial Acetylene Company, 80 Broad Street, New York, and was attending the Air Brake Convention held in Detroit, Mich., when he was taken ill. Mr. Paterson was one of the most popular men connected with a railroad paper and his genial smile will be missed not only by his close personal friends, but also at the June conventions, where he was always a prominent figure. Good, big-hearted "Pat," with a smile and a handshake of welcome for all he met or knew, was the kind of man not easy to forget.

## SUMMERS MOTOR DRIVEN ORE CAR.

Two Summers ore cars of the same type as described on page 49 of the February and page 338 of the August, 1909, issues of this journal have recently been equipped with motor trucks and complete electrical equipment for their propulsion and control.

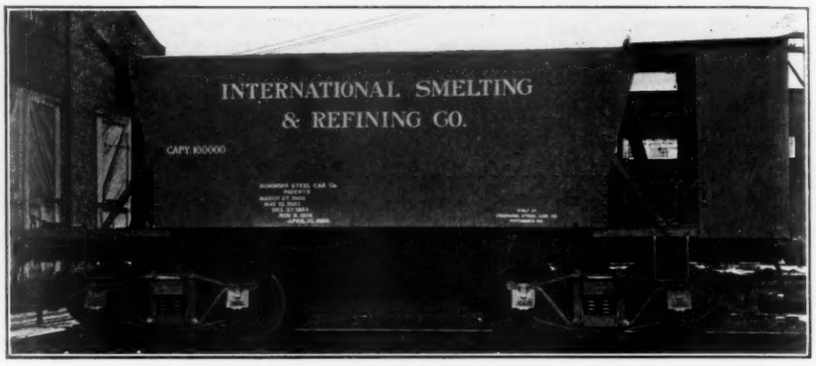
These cars were designed for hauling copper ore from a cableway terminal to storage bins over a 1¼ per cent. grade, with an estimated maximum speed of 8.5 miles per hour.

As the haul is of comparatively short length, the car will dump often, and particular attention has been paid to facilitate the easy operation of the doors; these are operated by a crank conveniently located on the end platform, connecting, by means of an endless steel chain to suitable gearing, one man only being needed to run each car and operate the doors at the storage bins.

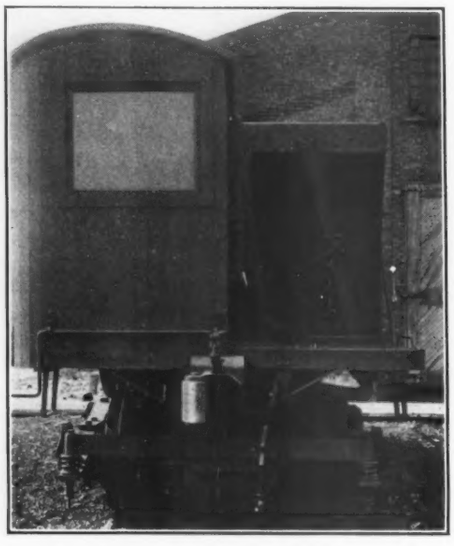
The electrical equipment consists of two 35 horsepower type K 101 Westinghouse 500 volt, series RW type motors, mounted one on each truck and geared 14 to 79. One series-parallel controller, the necessary resistance grids, circuit breaker, etc., are all conveniently located in the cab. Current will be collected from a trolley wire located about 22 feet above the tracks, with rail return.

A powerful hand brake, with shoes on all wheels, form the brake arrangement of the car.

These units will each handle approximately 30 cubic yards of ore per trip and the dumping operation requires somewhat under a minute at the bins, which would indicate that the equipment would prove highly efficient. It is reported that even during the coldest weather this type of car, in the service of the ore carrying roads in the Northwest, after the 70 mile run from the mines to the docks, dumps its load without the usual delays incident to frozen ore.




SUMMERS ELECTRIC ORE CAR.



END VIEW OF ELECTRIC ORE CAR.

## BOOK NOTES.

Practice and Theory of the Indicator. Third edition. By Stricklan L. Kneass. 171 pages. Illustrated. Published by John Wiley & Sons, New York. Price, $1.50.

Since the publication of the second edition of this book two years ago there have been marked changes in the construction of locomotives, which have reacted upon the methods of feeding boilers and consequently upon the indicator design. The trend is now toward the non-lifting form of injectors and feed water heating is becoming popular, therefore this well-known book has been thoroughly revised and additional chapters and sections have been incorporated to bring it strictly up to date It deals most thoroughly with the theory of the injector, particularly as applied to locomotives. A chapter has been incorporated on feed water heating and the practice of handling injectors is very thoroughly considered.

"Electric Traction on Railways." By Philip Dawson, M. I. E. E., M. I. M. E. Handsomely and substantially bound in half leather. 855 pages, 6 x 9¼ in. Fully illustrated. Published by "The Electrician Co.," London. American agents, D. Van Nostrand Co., 23 Murray street, New York. Price, $9.00 net.

This book is an exhaustive treatise on the subject and goes fully into the advantages of the various systems of electrification and also the development of electric traction in England and in this country. It also fully discusses trolleys and methods of suspension, third rail systems and power and sub-stations. Thirty-seven pages are devoted to "Financial Considerations," giving careful comparisons of the working costs of steam and electric railroads, including maintenance of equipment and fuel, with data obtained from leading English and American railroads.

## PERSONALS.

Frank Rush has been made district master mechanic of the Chicago, Milwaukee & Puget Sound Railway on the division west of Avery.

E. H. Spenger has been made assistant superintendent of motive power of the Butte, Anaconda & Pacific Railway, with office at Anaconda, Mont.

G. W. French has been appointed master mechanic of the St. Louis, Iron Mountain & Southern Ry. at Ferriday, La., vice R. L. Butler, transferred.

A. V. Manchester has been made district master mechanic of the Chicago, Milwaukee & Puget Sound Ry., with jurisdiction east of Harlowtown.

W. B. Lipscomb, foreman locomotive repairs at Selma, Ala., has been appointed master mechanic of the Southern Railway at Charleston, succeeding Mr. Kadie, transferred.

A. R. Ayers, asst. master mechanic of the Lake Shore & Michigan Southern Ry. at Elkhart, Ind., has been promoted to mechanical engineer to succeed Mr. Kendig, promoted.

L. B. Rhodes, master mechanic of the Georgia, Southern & Florida Railway, has resigned and that position is abolished.

C. H. Terrell, master mechanic of the Chesapeake & Ohio Ry. at Huntington, W. Va., has been appointed superintendent of motive power of the West Virginia general division.

W. F. Kaderly, master mechanic of the Southern Railway, has been appointed superintendent of motive power of the Georgia, Southern & Florida Railway, with office at Macon, Ga.

J. R. Gould, master mechanic of the Chesapeake & Ohio Ry. at Richmond, Va., has been appointed superintendent of motive power of the Virginia general division at the same place.

J. F. Walsh, superintendent motive power of the Chesapeake & Ohio Ry. at Richmond, Va., has been appointed general superintendent of motive power, with offices at the same place.

W. T. Smith, master mechanic of the Chesapeake & Ohio Ry. at Covington, Ky., has been appointed superintendent of motive power of the Kentucky general division, with office at Covington.

J. T. Carroll, master mechanic of the Lake Erie & Western R. R. at Tipton, Ind., has been appointed superintendent of motive power of the Baltimore & Ohio R. R., with office at Pittsburgh, Pa.

T. H. Goodnow, master car builder of the Lake Shore & Michigan Southern Ry. at Englewood, Ill., has been transferred to asst. master mechanic at Elkhart, Ind., vice A. R. Ayers, promoted.

W. P. Hobson, master mechanic of the Chesapeake & Ohio Ry. at Lexington, Ky., has been appointed master mechanic of the Cincinnati division at Covington, Ky., succeeding W. T. Smith, promoted.

H. G. Griffin, general shop inspector of the Lake Shore & Michigan Southern Ry. at Collinwood, has been promoted to supervisor of materials and coal, at Cleveland, vice J. W. Senger, transferred.

E. A. Murray, foreman machine department at Covington, has been appointed master mechanic on the Ashland division of the Chesapeake & Ohio Ry. at Lexington, Ky., succeeding Mr. Hobson, transferred.

B. H. Montgomery, asst. general foreman of the Collinwood shops on the Lake Shore & Michigan Southern Ry., has been promoted to general foreman locomotive shops, succeeding B. F. Kuhn, promoted.

B. F. Kuhn, general foreman locomotive shops of the Lake Shore & Michigan Southern Ry at Collinwood, Ohio, has been promoted to asst. superintendent Collinwood shops, vice F. H. Reagan, promoted.

A. J. Isaacks, master mechanic of the Chicago Great Western Ry. at Clarion, Iowa, has been appointed master mechanic of the southern division with headquarters at Des Moines, Ia., succeeding T. H. Yorke, resigned.

F. H. Reagan, asst. superintendent at Collinwood shops of the L. S. & M. S. Ry., has been promoted to master mechanic of the Lake Erie & Western R. R., with headquarters at Tipton, Ind., vice J. T. Carroll, resigned.

J. W. Senger, supervisor of materials and coal of the Lake Shore & Michigan Southern Ry. at Cleveland, has been promoted to master car builder, with headquarters at Englewood, Ill., vice Mr. Goodnow, transferred.

T. J. Hamilton has been made district master mechanic of the Chicago, Milwaukee & Puget Sound Railway, in charge of line from Harlowtown, Mont., to Avery, Ida.

J. W. Johnson, general foreman at Oelwein, Ia., has been appointed master mechanic of the Western division of the Chicago Great Western Ry., with headquarters at Clarion, Ia., succeeding Mr. Isaacks, promoted.

James S. Sheafe has been appointed engineer of tests of the Illinois Central R. R., the Indianapolis Southern R. R., and the Yazoo & Mississippi Valley R. R., with headquarters at the Burnside shops, Chicago, reporting to the general superintendent of motive power.

C. M. Hoffman, master mechanic of the Denver & Rio Grande R. R. at Grand Junction, Colo., has been appointed assistant superintendent of the Idaho division of the Oregon Short Line, in charge of motive power, with headquarters at Pocatello, Idaho, vice A. H. Gairns, resigned.

R. B. Kendig, mechanical engineer of the Lake Shore & Michigan Southern Ry. at Cleveland, has been promoted to general mechanical engineer of the New York Central Lines, with headquarters at Grand Central Terminal, New York, effective June 1st, succeeding Mr. Whyte, resigned.

D. R. MacBain, assistant superintendent of motive power of the New York Central & Hudson River R. R. at Albany, N. Y., has been appointed superintendent of motive power of the Lake Shore & Michigan Southern Ry., with office at Cleveland, Ohio, succeeding Le Grand Parish, whose resignation was announced in the last issue.

John H. Converse, president of the Baldwin Locomotive Works, died suddenly from heart disease at his suburban home in Rosemont, near Philadelphia, May 3. He was born in Burlington, Vt., in 1840, and was graduated from the University of Vermont in 1861, having become an expert in mechanical drawing and stenography. Mr. Converse entered the employ of the Chicago & Northwestern Ry. Co., and remained in Chicago for two years, until at the instance of E. H. Williams he entered the service of the Pennslyvania R. R. in Philadelphia. Later he became allied with Mr. Williams in the control of the Baldwin Locomotive Works, and when the latter retired from active direction of the company Mr. Converse took it up and carried it on with great success. Mr. Converse was also a well-known philanthropist, and it is estimated that he has given $500,000 to various charitable and public institutions. At the time of his death Mr. Converse was sixty-nine years of age.

Frederic M. Whyte, general mechanical engineer of the New York Central & Hudson River R. R., has resigned and will become general manager of the New York Air Brake Co., effective June 1. Mr. Whyte was born March 3, 1865, and entered railway service May 1, 1889, since which he has been consecutively to Jan. 1, 1890, draftsman motive power department Lake Shore & Michigan Southern Ry.; Jan. 1, 1890, to Feb. 1, 1892, testing department and drawing room Baltimore & Ohio R. R. at Baltimore; Feb. 1, 1892, to June, 1892, special testing work Mexican Central Ry., Mexico City; June, 1892, to December, 1894, general railroad engineering in Chicago, chiefly with South Side Elevated road and in railway newspaper work; July, 1895, to September, 1896, draftsman Northwestern Elevated road, Chicago; September, 1896, to July 1, 1897, consulting engineer, Chicago; July 1, 1897, to Aug. 10, 1899, mechanical engineer Chicago & Northwestern Ry. and secretary of the Western Railway Club; Aug. 16, 1889, to Nov. 1, 1904, mechanical engineer New York Central & Hudson River R. R.; Nov. 1, 1904, to date, general mechanical engineer same road, Lake Shore & Michigan Southern Ry., Boston & Albany, Lake Erie & Western, Indiana, Illinois & Iowa roads, and Rutland Railroad.

## CATALOGS.

IN WRITING FOR THESE PLEASE MENTION THIS JOURNAL.

ROOFING.—The H. W. Johns-Manville Co., 100 William St., New York City, has just issued a folder describing its J. M. asbestos fireproof roofing.

LIFTING JACKS.—An illustrated catalog is being sent out by the Joyce-Cridland Co., Dayton, O., describing its new hydraulic, ratchet and gear jacks up to 50 tons capacity.

FILING CASES.—A leaflet has recently been issued by the O. M. Edwards Co., of Syracuse, N. Y., which describes the "Paownyc" steel specialties, including some very practical and neat filing cabinets and other office furniture.

MORSE SILENT RUNNING CHAIN.—General bulletin No. 9 has been issued by the Morse Chain Company, Ithaca, N. Y., describing a variety of silent chain drives for transmitting from 3 to 1,000 h.p. This bulletin is thoroughly illustrated.

BELTING.—The Graton & Knight Mfg. Co., of Worcester, Mass., has recently issued a neat little folder showing its leather belting and leather packings. This company has had 54 years' experience in the leather manufacturing business.

LOCOMOTIVE BELLS.—A leaflet has recently been issued by the Vanadium Metals Company, Frick Bldg., Pittsburgh, which gives illustrations and a report of comparative tests demonstrating the superiority of Victor-Vanadium bronze bells.

RADIAL TRAILING TRUCK.—Bulletin No. 1003, issued by the American Locomotive Company, 30 Church St., New York City, describes the latest construction of radial trailing truck with outside bearings and illustrates its application to locomotives of the 4-6-2, 2-6-2 and 2-8-2 type.

BRONZE JOURNAL BEARINGS.—The Chicago Bearing Metal Co., Chicago, Ill., is sending out the No. 2 issue of "The Graphose Age," published every once in a while. It is a small 18-page publication containing some original philosophy and also exploiting Graphose Bronze for bearings.

CONVEYING MACHINERY.—The Jeffrey Mfg. Co. is issuing a small booklet No. 38, illustrating its various types of conveyors and showing the wide range of application. It also contains an index, giving numbers of special booklets describing the application of the Jeffrey methods to the different lines of industry.

ENGINE AND TURRET LATHES.—The Lodge & Shipley Machine Tool Co., Cincinnati, O., has issued general catalog No. 21, describing all its various new machine tools. The catalog presents a very artistic appearance, and is fully illustrated, showing clearly all the details of the new patent head lathes.

EMERGENCY AND RELEASE VALVES.—Bulletin No. 389, recently issued by the National Brake and Electric Company, Milwaukee, Wis., describes the National emergency and variable release valves. This bulletin also contains some good line drawings, showing the National air brake equipment for a motor car and trailer.

MACHINE SHOP TOOLS.—The Morse Twist Drill & Machine Co., New Bedford, Mass., has just issued a very complete catalogue for 1910 describing its new twist drills, taps, dies and cutters of all descriptions. This company is also sending out a very neat and useful little booklet entitled "The Young Machinist's Practical Guide."

WATER SOFTENER.—The Dodge Mfg. Co., Mishawaka, Ind., have recently issued a poster with a colored sectional view of the "Eureka" continuous and automatic water softener and purifier. This chart presents a very attractive appearance and illustrates clearly by means of the colors the complete process employed in the Eureka method of water softening.

TILTING CRUCIBLE MELTING FURNACE.—A very interesting pamphlet, entitled "Bulletin M," has been issued by the Rockwell Furnace Co., 26 Cortlandt St., New York. It describes a furnace for melting brass, aluminum, iron, etc., mounted on a strong frame by means of trunnions, and using oil or gas fuel. This furnace has many advantages which make it suitable for melting scrap brass liners in railroad work.

DEAN BOILER TUBE CLEANER.—A very complete series of tests made by Professor Kavanaugh, of the University of Minnesota, on the Dean boiler tube cleaner, is being issued in pamphlet form by William B. Pierce Co., 327 Washington St., Buffalo, N. Y. These tests were made with great care and accuracy and developed some very interesting results in connection with the cleaning of boiler tubes. Copies can be obtained upon request.

ELECTRIC HOISTS.—The Sprague Electric Co., 527 W. 34th St., New York City, has issued a 24-page catalog describing its labor-saving electric hoists, which can be used out of doors as well as inside for every purpose. The general catalog of this company, containing 200 pages, shows all the designs necessary to fill the various requirements, including railway machine shops and power plants. A small catalog illustrating the Sprague Flexible steel armoured hose is also being issued by the same company.

COLBURN BORING MILLS.—Rugged and powerful machines, built to withstand the heaviest cuts with high speed steel, and embodying many improvements for the rapid production of work, are shown in a catalog recently issued by the Colburn Machine Tool Co., Franklin, Pa. This catalog is confined to the new model boring and turning mill. It contains many photographs showing details of construction, each part being fully described. It forms most interesting reading and will be found to be of value to any shop superintendent or foreman.

GAS ELECTRIC MOTOR CAR.—The General Electric Company, Schenectady, N. Y., has recently issued a very attractive pamphlet, numbered 4730, describing a single truck type of gas electric car. The equipment consists of a direct coupled gas engine and generator with an exciter upon the same shaft, all completely enclosed and mounted between the axles of the truck and the car floor. This car is at present in regular service. This company is also issuing Bulletin No. 4729, illustrating and describing the various designs of Mazda diffusers. The special advantages of these lamps are said to be the wide range of capacity, relatively low intrinsic brilliancy with excellent diffusion and economical distribution of light.

## NOTES.

THE BETTENDORF AXLE CO.—This company has removed its offices from the Old Colony Bldg. to the McCormick Bldg., Chicago.

MCCORD & COMPANY.—The address of this company has been changed from old Colony Bldg., to People's Gas Building, Chicago.

WAUGH DRAFT GEAR CO.—This company announces the removal of its offices from 1525 Monadnock Block to Suite 809 People's Gas Building, Chicago.

CHICAGO RAILWAY EQUIPMENT CO.—The sales offices of the above company have been removed from the Fisher Bldg. to the McCormick Bldg., Chicago.

STANDARD COUPLER CO.—This company has removed its Chicago offices from the Fisher Building to 1005 People's Gas Building, corner of Michigan Ave. and Adams St.

WISCONSIN ENGINE COMPANY.—Benjamin K. Hough has been appointed Boston sales manager, representing the company in the New England States, with offices in the Oliver Building, Boston, Mass.

FIRTH-STERLING STEEL COMPANY.—It is announced by E. S. Jackman & Co., general agents for the above company at 710 Lake St., Chicago, that E. O. Reynolds and Joseph Smith will travel exclusively south and west of Denver and El Paso.

THE NORTH-WESTERN METAL MANUFACTURING COMPANY.—Alfred Munch, formerly secretary of this company, has been elected vice-president to succeed W. C. Schroder. R. E. Cook has been elected secretary and treasurer, with office at Minneapolis.

BURTON W. MUDGE & CO.—Herbert Green, who was vice-president of the Grip Nut Company until May 1, has been elected vice-president of the above company, with office at Chicago. Mr. Green will devote his time to the mechanical features of the devices of this company.

J. ROGERS FLANNERY & CO.—George E. Howard has been appointed eastern representative of the above company instead of the Flannery Bolt Company, as announced in the May issue. This company is the general sales agent for the Tate flexible staybolt manufactured by the Flannery Bolt Co., of Pittsburgh.

P. & F. CORBIN CO.—J. B. Comstock, for six years with the Westinghouse Electric & Manufacturing Company at its East Pittsburg Works, and for four years manager of its Publication Department, severed his connections with that company in April to accept a similar position with the above company, of New Britain, Conn. Prior to Mr. Comstock's connection with the Westinghouse Company, he filled the same position with this company that he has recently been recalled to assume.

WESTINGHOUSE, CHURCH, KERR & CO.—Walter C. Kerr, president of the above company, died on May 8 at Rochester, Minn., to which place he had gone to undergo an operation for cancer. Mr. Kerr was born at St. Peter, Minn., on November 8, 1858. He was educated in the public schools of that town and later went to Cornell University, where he was graduated in mechanical engineering in 1879. In 1883 he became allied with the Westinghouse interests. His forceful personality and gift of organization was responsible for the development of Westinghouse, Church, Kerr & Co. from its small beginning to its present place in the engineering operations of the world.

# FRONT END TESTS *

## RESULTS OF A SERIES OF TESTS ON THE LOCOMOTIVE TESTING PLANT AT ALTOONA TO DETERMINE THE BEST ARRANGEMENT OF FRONT ENDS FOR PENNSYLVANIA ATLANTIC TYPE LOCOMOTIVES, CLASSES E2a AND E3a.

*Draft and Back Pressure.*—In the tests made by the Master Mechanics' Committee† oil was used as fuel and by its use the admission of air to the fire-box could be completely controlled. With this method of oil firing the effectiveness of any arrangement could be derived from the draft indications; the draft in the smoke-box at any fixed back pressure being dependent only upon the smoke-box arrangement.

As the problem here was to devise an arrangement that would clear the smoke-box of cinders, the use of oil as a fuel could not be considered and with coal as a fuel it was found impossible to duplicate draft readings under apparently similar conditions of running.

By means of an indicator connected to the exhaust pipe a few inches below the nozzle the back pressure was observed, and by running the locomotive under gradually increasing loads a series of readings of the back pressure and the corresponding draft or vacuum in the smoke-box were obtained. These readings were plotted and a comparison of the results for light and heavy firing indicates very clearly that the draft is so closely dependent upon the conditions at the grate that it cannot be used as a basis of comparison for different front end arrangements when firing coal.

In estimating the comparative merits of the different devices tried it then became necessary to take account of a number of factors, as

The quantity of water that could be evaporated as compared with the standard front end.

The evaporation per pound of coal.

The general steaming of the locomotive as shown by the boiler pressure during a test.

From tests made with the standard front end it was known that the boiler could be expected to give an equivalent evaporation of about 16 pounds of water per square foot of heating surface with a friable coal and 18 pounds with a gas coal. To obtain the lower evaporation a speed of 160 revolutions per minute and a cut-off of 27 per cent. was required with locomotive No. 5266 with fully open throttle, and for the higher evaporation of 18 pounds, 160 revolutions and 32 per cent. cut-off with full throttle.

If the results with the standard front end could be equalled with a self-cleaning device the object of the tests would be accomplished, as with the added advantage of a self-cleaning front which would permit the use of a friable coal the capacity of the locomotive would not be reduced.

The tests were made with both a friable and a screened gas coal. The former was used for the preliminary runs, as with it large quantities of cinders are drawn through the tubes and the self-cleaning feature could be better observed than with a coal making less cinders.

The final series of tests were made with the gas coal, as it is one of the regular passenger coals.

The same fireman fired for all of the tests on locomotive No. 5266, with one exception, which will be noted later.

### THE TESTS.

#### THE EFFECT OF A MOVEMENT OF THE DIAPHRAGM EDGE WITH THE STANDARD FRONT END.

Before any changes were made in the standard front end (see Fig. 1) some trials were made to note the effect on the fire of a movement of the lower edge of the diaphragm plate. The normal position of this edge for locomotive No. 5266 is as shown, 21⅓ inches above the bottom of the smoke-box. The plate was lowered 5½ inches from this normal position, and after a short trial run it was raised 5¼ inches above the normal position and a trial made.

These changes in the position of the diaphragm plate produced no marked effect upon the burning of the fire. It burned evenly over the whole grate under each adjustment of the diaphragm, and the locomotive appeared to steam as freely with the plate in either the upper or the lower positions as it did under normal conditions.

The fact that the diaphragm is perforated may account for the lack of sensitiveness or marked effect upon the fire when the plate is given a new position.

#### PRELIMINARY TESTS.

The trials of front ends made by the Master Mechanics' Committee did not determine the arrangement of the diaphragm plate to make the smoke-box self-cleaning, and the first consideration in these tests was to investigate the shape of the diaphragm and its location in the smoke-box for this purpose.

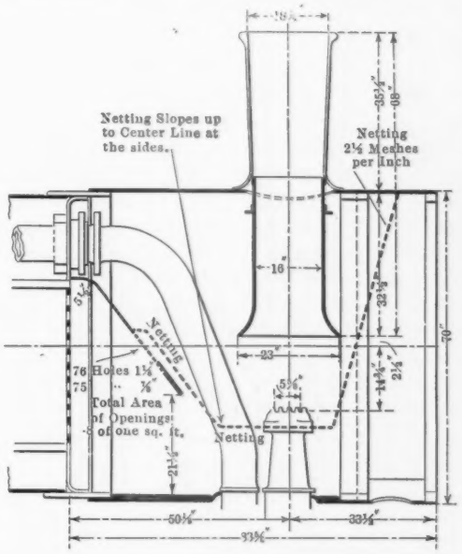



FIG. I.

A diaphragm of the general type recommended by the Committee as applied to this locomotive is shown on drawing Fig. 2. The whole diaphragm plate was without perforations, and, as first applied, extended beyond the center line of the nozzle a distance of 16¾ inches. At its end there was an angle and a plate 4¼ inches wide extending downward to a point 13¼ inches above the bottom of the smoke-box. The netting was omitted for these preliminary trials.

With the arrangement as described above a test was made (No. 900.25), using a friable coal and working the boiler at about the limit of its capacity to maintain a good pressure. The arrangement was found to be perfectly self-cleaning, there being no cinders at all left in the bottom of the smoke-box.

An inside stack according to the Master Mechanics' recommendations was then applied, and without other changes, a test (No. 900.26) was made at the same speed and cut-off as before.

* A brief summary of the conclusions of these tests appeared on page 227 of the June issue.

† See AMERICAN ENGINEER, June, 1906, page 228.

The exhaust nozzle was then changed from 5⅝ inches diameter to 5⅞ inches diameter, but after but a few minutes of running with this large nozzle it was evident on account of the falling pressure that the nozzle was too large to give sufficient draft.

The nozzle was then reduced to 5¾ inches diameter and without other changes a test was made at a lower rate of evaporation than the earlier tests.

This arrangement was found to steam fairly well and to be perfectly self-cleaning.

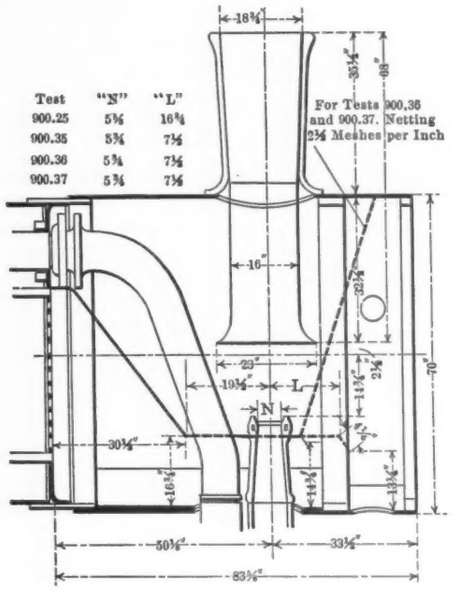



FIG. 2.

The smoke-box was then fitted with a stack that was exactly according to the Master Mechanics' recommendations (in the tests just mentioned the inside stack only had conformed to these recommendations). With this Master Mechanics' stack (Fig. 3) tests with 5¾-inch and 5⅞-inch exhaust nozzles were made, tests Nos. 900.29, 900.30 and 900.31. In these tests it was observed that while the cinders were all blown out of the front and there appeared to be a higher velocity of the gases through the restricted passage under the edge of the diaphragm than would be necessary for this purpose, or there was a large difference between the draft front and back of the diaphragm, indicating that too great a resistance to the passage of the gases was caused by the length of the diaphragm plate.

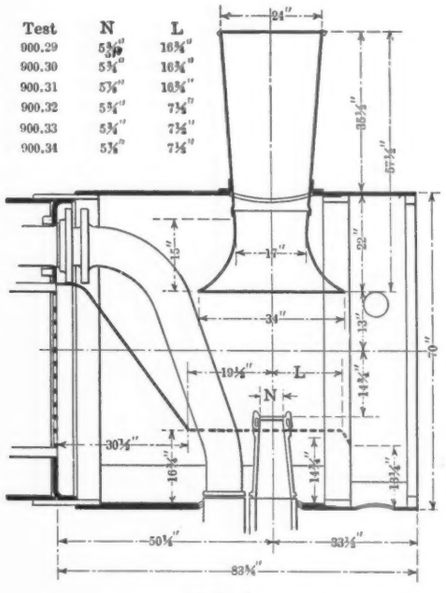



FIG. 3.

The plate was then cut off until it extended but 7½ inches in front of the exhaust nozzle center.

Tests Nos. 900.32, 900.33 and 900.34 were then run and in the table below the resulting draft readings are given:

TABLE NO. 1.
DRAFT IN FRONT END—FRIABLE COAL.

| Test No. | R. P. M. | Cut-Off. | Throttle. | Duration of test, hours. | Draft in inches. Front of diaphragm. | Smoke-box, In of Water. Back of diaphragm. | Difference between F and B. | Cinders collected in smoke-box, lbs. per hour. |
|---|---|---|---|---|---|---|---|---|
| 900.25 | 160 | 27 | Full | 1.5 | 4.9 | 3.2 | 1.7 | 0 |
| 900.26 | " | " | " | 1.0 | 4.8 | 3.3 | 1.5 | 0 |
| 900.30 | " | " | " | 1.0 | 5.3 | 3.7 | 1.6 | 0 |
| 900.31 | " | " | " | 1.5 | 4.8 | 3.4 | 1.4 | 0 |
| 900.32 | " | " | " | 1.0 | 5.2 | 4.3 | .9 | 48 |
| 900.34 | " | " | " | 0.5 | 5.0 | 4.3 | .8 | .. |
| 917.* | | | | 3.0 | 7.7 | 6.2 | 1.5 | 492 |

* Standard front end.

While, in general, as has been explained, the draft indications cannot be depended upon as comparative, it appears from these figures that when the diaphragm plate was shortened just before test No. 900.32, that there was a marked decrease in the difference between the draft front and back of the diaphragm, and that the effective draft, or the draft back of the diaphragm, was increased.

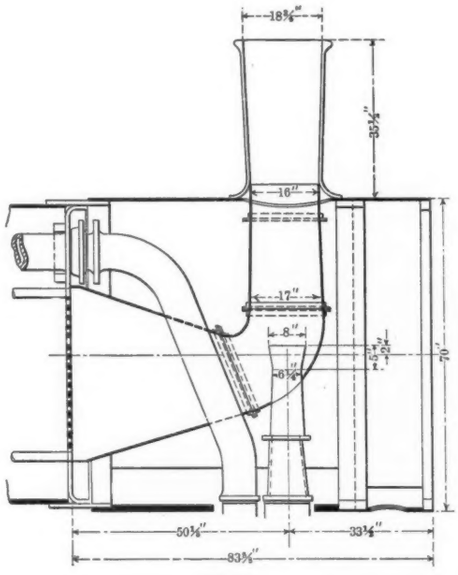



FIG. 4.

Test No. 917 was run with the same kind of coal as the others, but with the old form or standard front end.

In test No. 900.32 there were 48 pounds of cinders in the smoke-box, indicating that the plate was now as short as it could be made for self-cleaning.

The smoke-box arrangement was then made as shown in Fig. 2, the standard stack and inside stack being substituted for the Master Mechanics' form. A netting was put in with this arrangement.

Up to this time the netting had been omitted so as to simplify operations in making changes in the front end arrangement. It was assumed that the netting would have no effect upon the action of the front end, except to break up the large sparks, and this was confirmed later when the netting was applied.

After making two tests with this arrangement, the diaphragm plate was raised up in the smoke-box, the exhaust nozzle being lengthened to suit the new height of diaphragm. At the front edge the plate measured 20½ inches above the bottom of the smoke-box. With the diaphragm in this position the locomotive steamed well, but there were 255 pounds of cinders collected in the smoke-box per hour.

Without moving the main diaphragm plate, an inclined plate

was fitted to its forward edge. This plate extended down to a point 15½ inches above the bottom of the smoke-box. The area of opening for the passsage of gases was then about the same as in the arrangement shown in Fig. 2, and it was expected that the results would be the same as with the whole diaphragm in the lower position, but from the test with this arrangement it was evident that the two arrangements, while giving the same area for the passage of gases, are by no means equivalent as in the last test the locomotive did not steam well, and there were 76 pounds of cinders collected in the smoke-box.

It would appear, then, that when changes are made in the height of diaphragm the whole plate should be raised and not the forward edge alone.

The plate without the movable defector presents, for the flow of gases, a passage free from obstructions or abrupt changes of form, and it is probable that this will account for the better results had with it than with the plate set high in the smoke-box, but having the movable edge plate.

Following still further the idea of making a smooth and direct

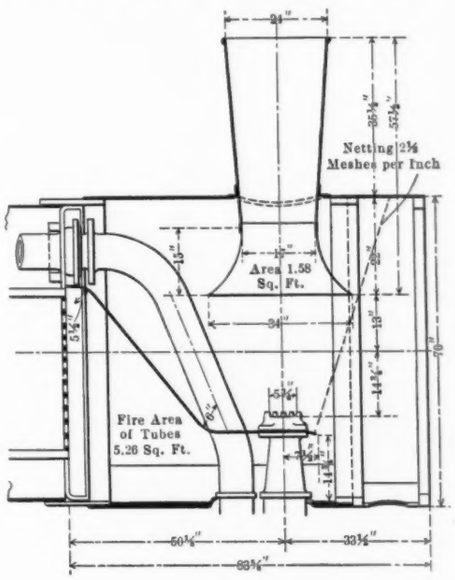



FIG. 5.

passage for the gases to the stack, the arrangement shown in Fig. 4 was applied. This consists of a conical pipe from the tube sheet carried forward and turning upward and connecting at its smaller end directly to the stack.

The exhaust nozzle for this arrangement was made with a flared tip, so that it would act as an expanding nozzle to convert the pressure energy of the steam into velocity without loss, in that way obtaining the most efficient exhaust jet.

A test was then made with this apparatus. It was very effective in discharging cinders, but the nozzle was found to be too large to make the locomotive steam. The sparks discharged from the stack were at a red heat and to break up these and reduce their temperature a netting was put in the pipe back of the exhaust nozzle and the nozzle reduced in diameter. The netting could not be very large in area on account of the limited space, and it was found that the area of the opening through it was too small for practical purposes.

Nothing further was done with this arrangement, as it was not considered of value if a netting could not be used in it.

A diverging or flared tip nozzle was again tried with a diaphragm arranged as in Fig. 7, but with a Master Mechanics' inside stack. The smallest diameter of this nozzle was 5¾ inches, with a taper to the top of about one in six. The locomotive did not steam well with this nozzle, though the back pressure below the nozzle was reduced.

To make the locomotive steam it would have been necessary to further reduce the nozzle diameter, but as it was then as small as the straight nozzle, it was not reduced, and no further trials of it were made.

FINAL TESTS.

After the preliminary trials of the various devices that have been described, three of those which were of greatest promise were selected for further tests. These arrangements are shown in Figs. 5-6-7.

Figure 5 shows the front end recommended by the Master

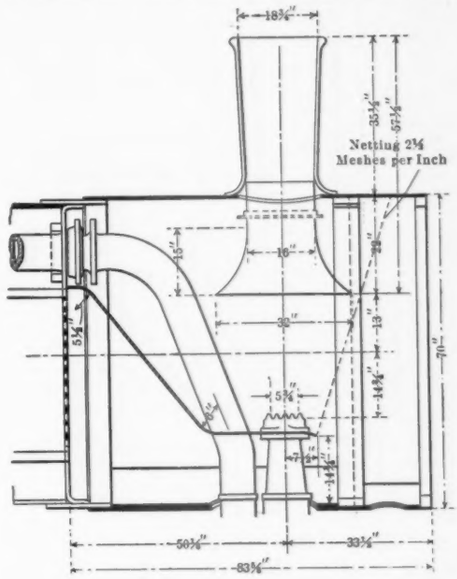



FIG. 6.

Mechanics' Association as applied to the "E2" or "E3" locomotive. It has a tapered stack with a wide mouthed inside stack. The diaphragm plate is without perforations and is carried down and forward to a point 7½ inches in front of the exhaust nozzle center. The edge of the plate ends at a point 14¾ inches above the bottom of the smoke-box and the area of the passage for the gases at this restricted point is three-fourths of the area of the tube opening or fire area.

The tests made with these three arrangements were each of two hours duration at 160 revolutions per minute, or about 38 miles per hour. Tests Nos. 900.41 to 900.44 were run at the same cut-off with full throttle. A gas coal was used for all.

The results of these tests are given in the data sheets on the following page.

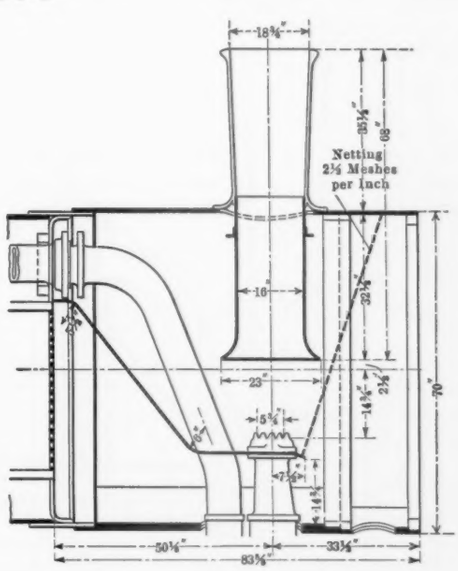



FIG. 7.

Good results were obtained with each of these arrangements. They were all perfectly self-cleaning except for a slight accumulation of cinders on the horizontal plate of the diaphragm.

## RESULTS OF FINAL TESTS TO DETERMINE THE BEST DESIGN OF FRONT END ARRANGEMENT ON CLASS "E" LOCOMOTIVES

| TEST NO. | 900.41 | 900.42 | 900.43 | 900.44 | 900.45 | 900.46 | 900.47 | 1,001 | 1,002 | 1,003 | 1,004 | 1,005 | 1,006 | 1.007 | 1,008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locomotive No. | 5,266 | 5,266 | 5,266 | 5,266 | 5,266 | 5,266 | 5,266 | 2,984 | 2,984 | 2,984 | 2,984 | 2,984 | 2,984 | 2,984 | 2,984 |
| Speed in M. P. H. | 37.56 | 37.56 | 37.56 | 37.56 | 37.56 | 37.56 | 37.56 | 46.27 | 37.02 | 37.02 | 37.02 | 27.76 | 37.02 | 37.02 | 46.27 |
| Throttle opening, full or partial | Full | Full | Full | Full | Full | Partial | Full | Full | Full | Full | Full | Full | Full | Full | Full |
| Back pressure in exhaust pipe, lbs. | 2.15 | 1.90 | 2.03 | 1.71 | 3.53 | .15 | .78 | | | | | | | | |
| Average boiler pressure | 200.8 | 203.4 | 204.6 | 202.3 | 199.5 | 203.8 | 195.8 | 199.6 | 201.9 | 200.5 | 199.9 | 202.7 | 200.4 | 200.4 | 202.7 |
| Quality of steam in dome | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 | .9860 |
| Draft, front of diaphragm | 6.9 | 6.7 | 7.1 | 6.8 | 8.7 | 1.8 | 5.7 | 8.6 | 8.7 | 7.2 | 6.7 | 3.6 | 7.2 | 5.6 | 7.1 |
| Draft, back of diaphragm | 5.5 | 5.2 | 5.6 | 5.4 | 6.7 | 1.5 | 4.6 | 6.1 | 5.9 | 5.3 | 4.9 | 2.7 | 5.2 | 4.3 | 5.6 |
| Draft in firebox | 2.1 | 1.9 | 2.0 | 1.9 | 2.5 | .6 | 1.9 | 2.3 | 2.2 | 1.8 | 1.9 | 1.2 | 2.2 | 1.8 | 2.2 |
| Draft in ash pan | .3 | .3 | .3 | .3 | .4 | .2 | .3 | .3 | .3 | .3 | .4 | .2 | .4 | .3 | .4 |
| Total lbs. of fuel fired | 9,115 | 7,895 | 9,424 | 7,667 | 9,744 | 2,886 | 8,184 | 5,607 | 4,386 | 3,856 | 7,721 | 5,082 | 4,569 | 4,513 | 5,093 |
| Dry fuel fired per hour, lbs. | 4,489 | 3,888 | 4,641 | 3,776 | 4,799 | 1,421 | 4,030 | 5,523 | 4,321 | 4,577 | 3,803 | 2,503 | 4,501 | 4,409 | 5,016 |
| Dry fuel fired per sq. ft. of G. A. per h., lbs. | 80.88 | 70.05 | 83.62 | 68.04 | 86.47 | 25.60 | 72.61 | 99.51 | 77.86 | 82.47 | 68.52 | 45.10 | 81.10 | 79.44 | 90.38 |
| Cinders collected in smoke box, lbs. per hour | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sparks discharged from stack, lbs per hour | 285 | 193 | 275 | 189 | 303 | 17 | 360 | 467 | 172 | 200 | 135 | 59 | 244 | 472 | 293 |
| Analysis of smoke box gases, oxygen | 7.1 | 6.9 | 10.1 | 9.6 | | 10.0 | 4.3 | | | | | | | | |
| Analysis of smoke box gases, carbon monoxide | 0 | .1 | Trace | .2 | | 0 | .3 | | | | | | | | |
| Analysis of smoke box gases, carbon dioxide | 10.9 | 10.3 | 8.6 | 8.4 | | 9.0 | 11 7 | | | | | | | | |
| Analysis of smoke box gases, nitrogen | 82.1 | 83.1 | 81.3 | 81.9 | | 81.0 | 83.7 | | | | | | | | |
| Lbs. of feed water delivered to boiler | 62,330 | 59,411 | 62.063 | 60,873 | 69,351 | 28,411 | 57,763 | 34,088 | 33,330 | 26,735 | 60,000 | 41.645 | 32,375 | 25,970 | 33,695 |
| Temperature of feed water | 64.8 | 64.8 | 63.9 | 63.8 | 64.4 | 67.1 | 65.2 | 56.2 | 57.4 | 54.8 | 53.0 | 52.6 | 49.8 | 56.4 | 48.6 |
| Lbs. steam delivered by boiler per hour | 31,165 | 29,706 | 31.032 | 30,437 | 34,676 | 14,206 | 28,882 | 34,088 | 33,330 | 32,211 | 30,000 | 20,823 | 32,375 | 25,970 | 33,695 |
| Dry steam per hour per sq. ft. H. S. | 13.30 | 12.68 | 13.25 | 12.99 | 14.80 | 6.06 | 12.33 | 14.55 | 14.23 | 13.75 | 12.81 | 8.89 | 13.82 | 11.09 | 14.38 |
| Dry steam per hour per lb. dry fuel | 6.87 | 7.56 | 6.62 | 7.98 | 7.15 | 8.90 | 7.09 | 6.11 | 7.64 | 6.97 | 7.81 | 8.24 | 7.12 | 5.83 | 6.65 |
| Equivalent evaporation per hour | 37,282 | 35.552 | 37,177 | 36,458 | 41,497 | 16,970 | 34,525 | 41,111 | 40,142 | 38,870 | 36,255 | 25,183 | 39,237 | 31,297 | 40,891 |
| Equivalent evaporation per hr. per sq. ft. H. S. | 16.07 | 15.33 | 16.03 | 15.72 | 17.89 | 7.32 | 14.89 | 17.73 | 17.31 | 16.76 | 15.63 | 10.86 | 16.92 | 13.49 | 17.63 |
| Equivalent evaporation per lb. dry fuel | 8.31 | 9.14 | 8.01 | 9.66 | 8.65 | 11.94 | 8.57 | 7.44 | 9.29 | 8.49 | 9.53 | 10.06 | 8.72 | 7.10 | 8.15 |
| Equivalent evaporation per lb. combustible | 8.96 | 9.87 | 8.65 | 10.42 | 9.33 | 12.89 | 9.24 | 8.14 | 10.16 | 9.29 | 10.42 | 11.00 | 9.53 | 8.94 | 8.70 |
| Boiler H. P. | 1080.7 | 1030.5 | 1077.6 | 1056.8 | 1202.8 | 491.9 | 1000.7 | 1191.7 | 1163.6 | 1126.7 | 1050.9 | 730.0 | 1137.3 | 907.2 | 1185.3 |
| Efficiency of boiler | 55.80 | 61.38 | 53.79 | 64.87 | 58.09 | 80.18 | 57.55 | 51.00 | 63.69 | 58.20 | 65.33 | 68.97 | 59.78 | 57.54 | 53.85 |
| Draw bar pull, lbs. | 10.822 | 10,334 | 10,250 | 10,400 | 11,967 | 3,994 | 10,142 | 10,397 | 12,914 | 12,717 | 11,876 | 10,957 | 12,765 | 10,605 | 10,109 |
| Draw bar H. P. | 1084.1 | 1035.3 | 1026.8 | 1041.9 | 1198.9 | 400.1 | 1016.0 | 1283.0 | 1274.9 | 1255.4 | 1172.4 | 811.3 | 1260.2 | 1046.6 | 1247.3 |
| Dry fuel per draw bar pull H. P. lbs. | 4.14 | 3.76 | 4.52 | 3.62 | 4.00 | 3.55 | 3.97 | 4.30 | 3.39 | 3.65 | 3.24 | 3.09 | 3.57 | 4.21 | 4.02 |
| Dry steam per draw bar pull H. P. lbs. | 28.46 | 28.39 | 29.66 | 28.91 | 28.63 | 34.63 | 28.13 | 26.26 | 25.87 | 25.40 | 25.32 | 25.40 | 25.34 | 24.49 | 26.66 |
| Thermal efficiency of locomotive, per cent | 4.27 | 4.71 | 3.91 | 4.89 | 4.42 | 4.98 | 4.46 | 4.20 | 5.33 | 4.95 | 5.58 | 5.85 | 5.06 | 5.07 | 4.33 |

## GENERAL DIMENSIONS OF THE LOCOMOTIVES ON WHICH THE TESTS WERE MADE.

| | | |
|---|---|---|
| Locomotive No. | 5266 | 2984 |
| Diameter of drivers | 80 | 80 |
| Driving wheel base, ft. | 7.42 | 7.42 |
| Total wheel base, ft. | 30.85 | 30.85 |
| Weight on truck | 37,167 | 33,700 |
| Weight on first drivers | 53,334 | 56,700 |
| Weight on second drivers | 56,667 | 61,500 |
| Weight, total, on drivers | 110,001 | 118,200 |
| Weight on trailers | 37,000 | 31,200 |
| Weight, total | 184,167 | 183,100 |
| Diameter of cylinders | 20.5 | 22 |
| Stroke | 26 | 26 |

| | | |
|---|---|---|
| Locomotive No. | 5266 | 2984 |
| Valves, type | Double Ported Bal. | Richardson Bal. |
| Type of valve gear | Stephenson | Stephenson |
| Valve travel, in. | 7 | .. |
| Lap of valve | 1.5 | .. |
| Inside clearance | .16 | .. |
| Diameter of boiler, first ring | 67 | 67 |
| Tubes, No. | 315 | 315 |
| Tubes, diameter, in. | 2 | 2 |
| Tubes, length, in. | 179.78 | 179.78 |
| Total fire area, tubes, sq. ft. | 5.26 | 5.26 |
| Boiler pressure | 205 | 205 |
| Grate area | 55.5 | 55.5 |
| Heating surface fire side of tubes | 2162.4 | 2162.4 |

| | | |
|---|---|---|
| Heating surface, firebox | 156.86 | 156.86 |
| Heating surface, total | 2319.26 | 2319.26 |
| Exhaust nozzle, diameter | 5.625 | 5.75 |
| Exhaust nozzle, area | 24.85 | 25.97 |

### ANALYSIS OF FUEL.

| Test No. | 900.41 to 900.47 | 1001 to 1008 |
|---|---|---|
| Fixed carbon, % | 56.52 | 56.11 |
| Volatile combustible, % | 34.74 | 33.99 |
| Moisture, % | 1.51 | 1.49 |
| Ash, % | 7.23 | 8.41 |
| Sulphur, separate, % | 1.67 | 1.53 |
| B. T. U. per lb. dry fuel | 14,382 | 14,088 |
| B. T. U. per lb. combustible | 15,529 | 15,403 |

There was some difficulty in keeping up the steam with the arrangement Fig. 5, test No. 900.41, but it will be noted that the boiler horsepower in this test was higher than for the others.

Test No. 900.44, with arrangement Fig. 7, shows a better evaporation per pound of coal than any of the others, and it was thought, all things considered, that this was the best arrangement.

Another test was then run with it to develop the maximum boiler capacity—test No. 900.45, at 160 revolutions and 32 per cent. nominal cut-off, and this test was run without difficulty. This is as late a cut-off as can be run with the standard front

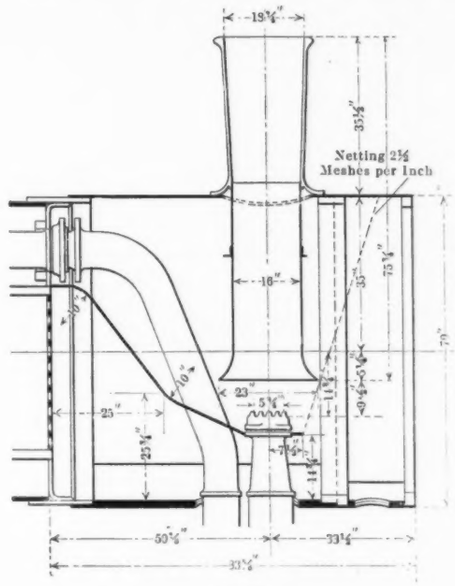



FIG. 8.

end at this speed, and as with arrangement (Fig. 7) the nozzle was ⅛ inch larger in diameter than was used with the standard arrangement, it is to be presumed that the boiler capacity is as great with this self-cleaning front as with the standard, with the added advantage of slightly decreased back pressure in the cylinders due to the large nozzle.

After this maximum capacity test a trial was made at a very low rate of working under partial throttle to note the effect of such conditions on the quantity of cinders collected in the smoke-box. This test, No. 900.46, at a speed of 160 revolutions, 27 per cent. cut-off and the steam throttled to one-half the boiler pressure, shows practically no cinders collected in the smoke-box.

### TESTS WITH DIFFERENT FIREMEN.

To show that the results obtained with this self-cleaning front were not due to good firing alone, tests Nos. 900.42 and 900.43, with the arrangement shown in Fig. 6, were run under precisely the same conditions, with the exception that test No. 900.42 was fired by the regular testing plant fireman, while No. 900.43 was fired by an inexperienced man who had been firing but two months and had never fired this class of locomotive.

The results of these two tests show that the good steaming of the locomotive with this self-cleaning front can be obtained by the average fireman, but they also show that the inexperienced man may use as much as 750 pounds of coal per hour over the amount actually required.

### SELF-CLEANING FRONT END OF "E3A" CLASS.

At this point, after tests which indicated that for locomotive No. 5266, "E2a" class, the self-cleaning front (Fig. 7) would give the best results, it was thought best to determine if this arrangement would give equally good results if applied to another boiler of the same class. Locomotive No. 5266, class "E2a," was, therefore, removed from the plant and put into road service equipped with arrangement (Fig. 7) and "E3a," locomotive No. 2984, fitted with the same arrangement, was placed on the plant.

Test No. 1001, with locomotive No. 2984, gave an evaporation that was practically the same as obtained with locomotive No. 5266, namely, 17.9 pounds equivalent evaporation per square foot of heating surface per hour. The locomotive steamed freely, maintaining a fairly uniform boiler pressure, and there were no cinders in the smoke-box except a small quantity on the horizontal plate of the diaphragm.

This test did not appear to be quite up to the limit of boiler capacity, and had it been possible the cut-off would have been extended, but it was found for this locomotive that the friction brakes were working up to their limit and no more power could be absorbed by them.

Another test, No. 1002, was then made with this arrangement at slightly lower power.

From these two tests, though they were not quite up to the maximum evaporation of the other locomotive, one of them was but five-tenths of a pound less per hour, and it is clear that this boiler will give the same results as the other with this front end.

Modifications of the diaphragm were then taken up to make it of such a shape that it would clear itself of the small quantity of cinders which had been collecting on it.

The plate was made sloping where in the earlier form it had been flat, just back of the exhaust nozzle. This modification of the form of the sheet did not have the desired effect, for in tests Nos. 1003 and 1004 with it, there was as large a quantity of cinders on the plate as before the change.

The inside stack was then lengthened as shown in Fig. 8, where the end of the stack is 7¼ inches above the tip of the nozzle. This adjustment had the desired effect, and in tests Nos. 1005 and 1006 the cinders were practically all cleared from the plate.

The inside stack was then raised, as in Fig. 9, to a point 12 inches above the nozzle, to find the highest position for this inside

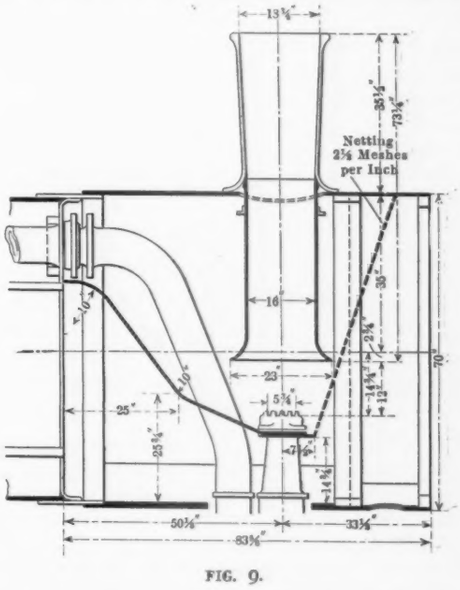



FIG. 9.

stack that would clear the plate of cinders. Six shovelfuls of dry cinders were put on the plate and the locomotive run at a speed of about 120 revolutions, and a short cut-off for about 15 minutes, when the cinders were all removed; next, six shovelfuls of wet cinders were put in, and these were also cleared from the plate.

A test, No. 1007, was then made, using a slack coal of very small size to note the effect of the self-cleaning feature. At the end of this test, with 472 pounds of sparks discharged from the stack, there were a few pounds of cinders on the plate and very little in the bottom of the smoke-box.

A test was then made, No. 1008, to observe if the capacity of the boiler had been reduced by the changes that had been made. This test gave an equivalent evaporation of 17.63 pounds per hour, or practically the same as in test No. 1001, with the arrangement last tried on locomotive No. 5266.

Locomotive No. 2984 was then removed from the plant and went into road service equipped with the device Fig. 9.

In the table following some of the results of the tests of the

final form of the self-cleaning front are shown in comparison with the standard front. The tests are in two groups, those with the friable coal being made at a shorter cut-off or lower evaporation than those with the gas coal.

TABLE NO. 2.
SELF-CLEANING FRONT COMPARED WITH STANDARD.

| R. P. M. | Cut-off Ins. | Throttle. | Duration of test. Hours. | Speed in miles per hour. | Front end arrangement. Figure number. | Cinders collected in smoke-box. Pounds per hour. | Sparks discharged from stack. Pounds per hour. | Boiler pressure. Pounds per square inch. | Evaporation, Dry Steam per sq.ft. of heating surface. Lbs. per hour. | Equivalent evaporation per sq. foot of heating surface. Pounds per hour. | Equivalent pound of dry coal. | Coal fired. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 27 | Full | 3 | 38 | 1 | 492 | 140 | 188.4 | 12.24 | 15.0 | 7.25 | Friable |
| 160 | 27 | Full | 1 | 38 | 2 | 10 | 529 | 199.9 | 12.25 | 14.76 | 7.28 | " |
| 160 | 27 | Full | 1 | 38 | 2 | 10 | 485 | 198.6 | 12.09 | 14.54 | 7.87 | " |
| 160 | 32 | Full | 2 | 38 | 1 | 326 | 341 | 201.2 | 15.04 | 18.24 | 7.01 | Gas |
| 160 | 32 | Full | 1 | 38 | 2 | 6 | 516 | 204.1 | 15.08 | 18.17 | 7.39 | " |
| 160 | 32 | Full | 2 | 38 | 7 | 0 | 303 | 199.5 | 14.80 | 17.89 | 8.65 | " |
| 200 | 25 | Full | 1 | 46 | 7 | 0 | 467 | 199.6 | 14.55 | 17.73 | 7.33 | " |
| 200 | 25 | Full | 1 | 46 | 9 | 0 | 293 | 202.7 | 14.38 | 17.63 | 8.15 | " |

CONCLUSIONS.

A front end arrangement has been developed for the "E" class which, while self-cleaning, maintains the boiler capacity or maximum evaporation fully equal to that with the standard front end arrangement.

With friable coals where large quantities of cinders are formed, the boiler capacity will be increased on long runs, on account of the smoke-box being kept clear of cinders which would obstruct the draft.

The front end arrangement recommended for the "E" class of locomotives is that shown in Fig. 9 to be used with an exhaust nozzle of 5¾ inches diameter. )

The outside and inside stacks as now used on this class of locomotive appear to give better results than can be obtained with the form recommended by the Master Mechanics' Committee, and it is thought advisable to retain them.

The best results were obtained when the passage for the gases under the diaphragm was smooth and free from abrupt changes of form.

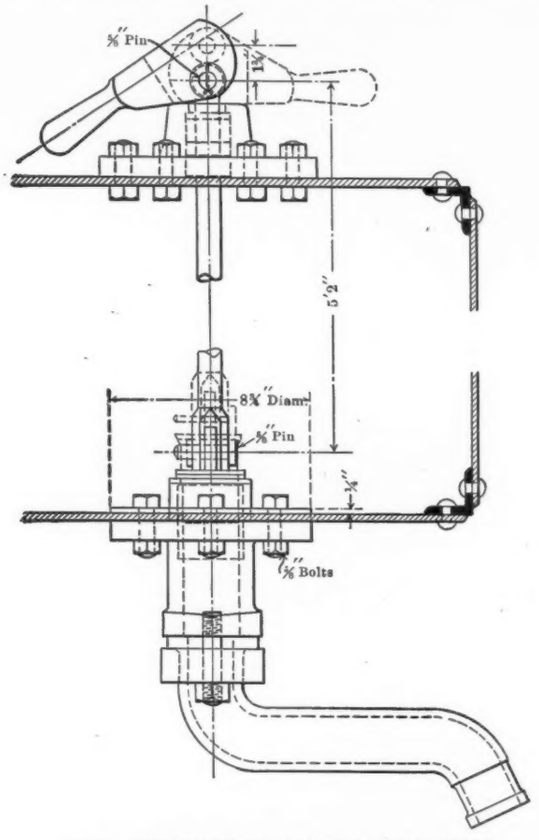
The inclined adjustable diaphragm plate, often used, was found to cause an obstruction to the flow of gases and is undesirable. In the experiments made the height of the whole horizontal plate of the diaphragm was varied and the final position recommended is suitable for any locomotive of this class and any means for adjustments is not considered necessary.

TOOLROOM MESSENGER SERVICE.—We have a system in Cleveland known as the material delivery gang system; it consists of a foreman at $60 a month, two assistants at 17 cents an hour, four helpers at 13½ cents an hour, and one messenger boy at 10 cents an hour. We do not allow a mechanic or helper to go to the storeroom. We have twelve miles of industrial track around our plant. A foreman must anticipate his wants 30 minutes in advance, with the exception of the roundhouse foreman, where there is a 10-minute delivery. A foreman may want 12 nuts delivered to engine 1250. At intervals through our plant we have little red boxes. He makes out his order and puts it in one of these. The messenger boy takes it up and the material is delivered to the engine, or wherever it is to be used. It costs us on an average of 2½ cents per order. I think if the general foremen would do this they would find a great saving. A good many of the laborers we have are foreigners, and when they went to the storeroom did not know what they wanted. In the morning we make every man go to the tool room and draw the necessary tools for the job he left the night before. He is not allowed to go to the tool room again before night. We have the same system in the machine shop. We have one boy who takes back all the tools that the mechanic is through with and sees to the drawing of new tools.—*J. A. Boyden at the General Foremen's Convention.*

## A NEW TANK VALVE ARRANGEMENT.

Difficulty is sometimes experienced with the ordinary arrangement of tank valves, which are designed on the plug cock principle to open by the revolving of a handle, in that the valve would become partially clogged up and the fireman would lift the rod and valve in order to clear it with the usual result of unseating it.

To eliminate this difficulty and at the same time improve and simplify the construction at this point, the mechanical engineer's office of the Atlantic Coast Line has designed a valve which lifts by the action of a cam shaped handle. This valve has a beveled seat and provided with wings to permit a 1¾ in. lift. The valve stem guide at the top of the water leg and the valve




NEW TANK VALVE ON ATLANTIC COAST LINES.

stem itself are so constructed that a boss on the stem strikes the top of the guide at the maximum lift and prevents the possibility of the valve being lifted too far. The illustration shows the construction on a tank with the water leg and on a water bottom tank without side water legs, the arrangement includes a cast iron column passed up through the tool box compartment, being in other ways the same as that illustrated. With this arrangement the valve can be ground while in place and the splashing of water out around the valve rod is prevented.

## PROGRESS OF ELECTRIC RAILWAYS.

On December 31, 1908, the length of the steam railroads of the United States was 232,045.9 miles. Accurate figures for electric railroads are not available, but on approximately the same data the length of the street and interurban railroads was in round figures, 35,000 miles. On a mileage basis the electric railroads shrink into insignificance and a comparison of gross earnings gives them a not much better showing. The gross receipts of the steam railroads in 1908 amounted to $2,590,400,124. The gross receipts of the electric railroads are less than one-sixth of that amount, being $440,000,000 annually. Practically all of that amount is passenger earnings which compares with passenger earnings of the steam railroads amounting to $575,246,516. On that basis the electric railways make a more favorable showing.

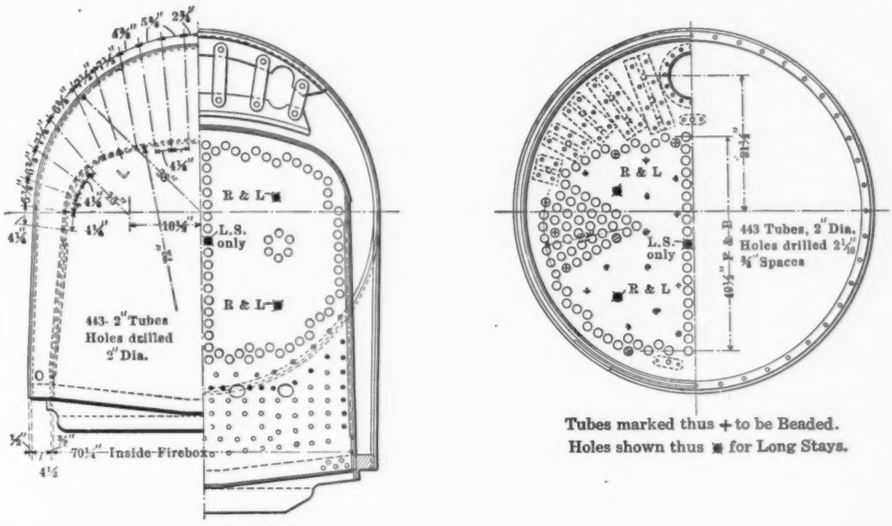
# PACIFIC AND CONSOLIDATION TYPE LOCOMOTIVES.

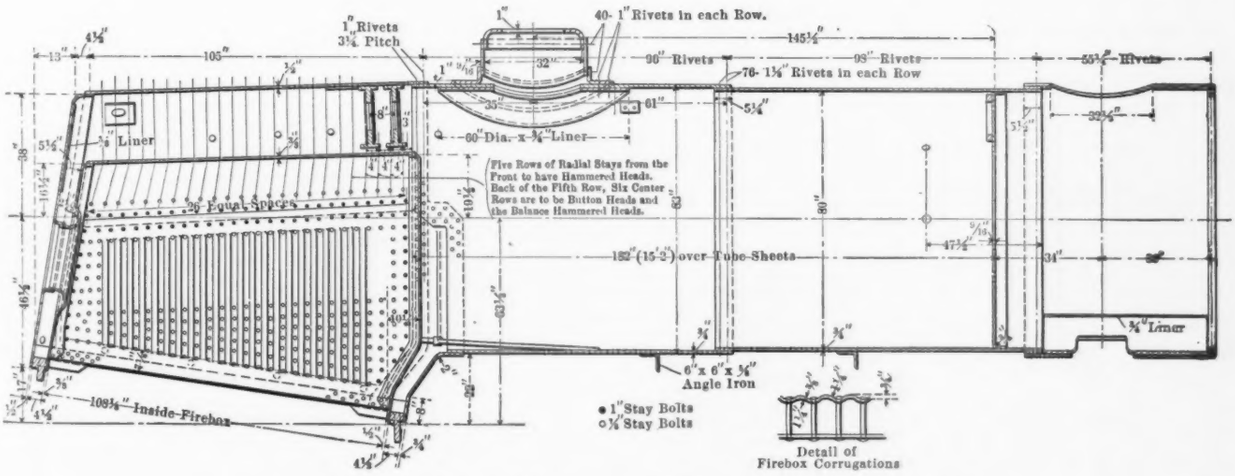
CHICAGO & NORTHWESTERN RAILWAY.

As one of the largest and most important American railway systems, the Chicago & Northwestern Railway is in a unique position in regard to its locomotive equipment. Up to recently this road has not owned any locomotives of either the Pacific or consolidation types, differing in this respect from practically every other large railroad in this country. The passenger traffic has been handled by powerful Atlantic type engines for high speed work and the ten-wheel locomotives for the heavier trains.* The freight traffic has been handled almost entirely by the ten-wheel type of locomotive.

Conditions of traffic have lately, however, made it advisable to employ larger train units and the American Locomotive Company has delivered an order of 25 Pacific and 40 consolidation locomotives to this company.

While, in view of the facts above stated, these locomotives are in a way experimental, there is practically nothing in the design of the passenger engines that is new or novel. They have 23x28 in. cylinders with 190 lbs. steam pressure, 14 in. piston valves and weigh 245,000 lbs., of which 151,000 is on drivers. The design is very similar to the locomotives of the same type which were built by the American Locomotive Co. for the Chicago & Alton Railway and were illustrated in the July, 1909, issue of this journal, page 268. The most noticeable difference is the employment of 75 in. drivers instead of 80 in. A careful examination of the general dimensions and ratios indicates that the vital importance of sufficient boiler capacity has been well recognized in both cases.

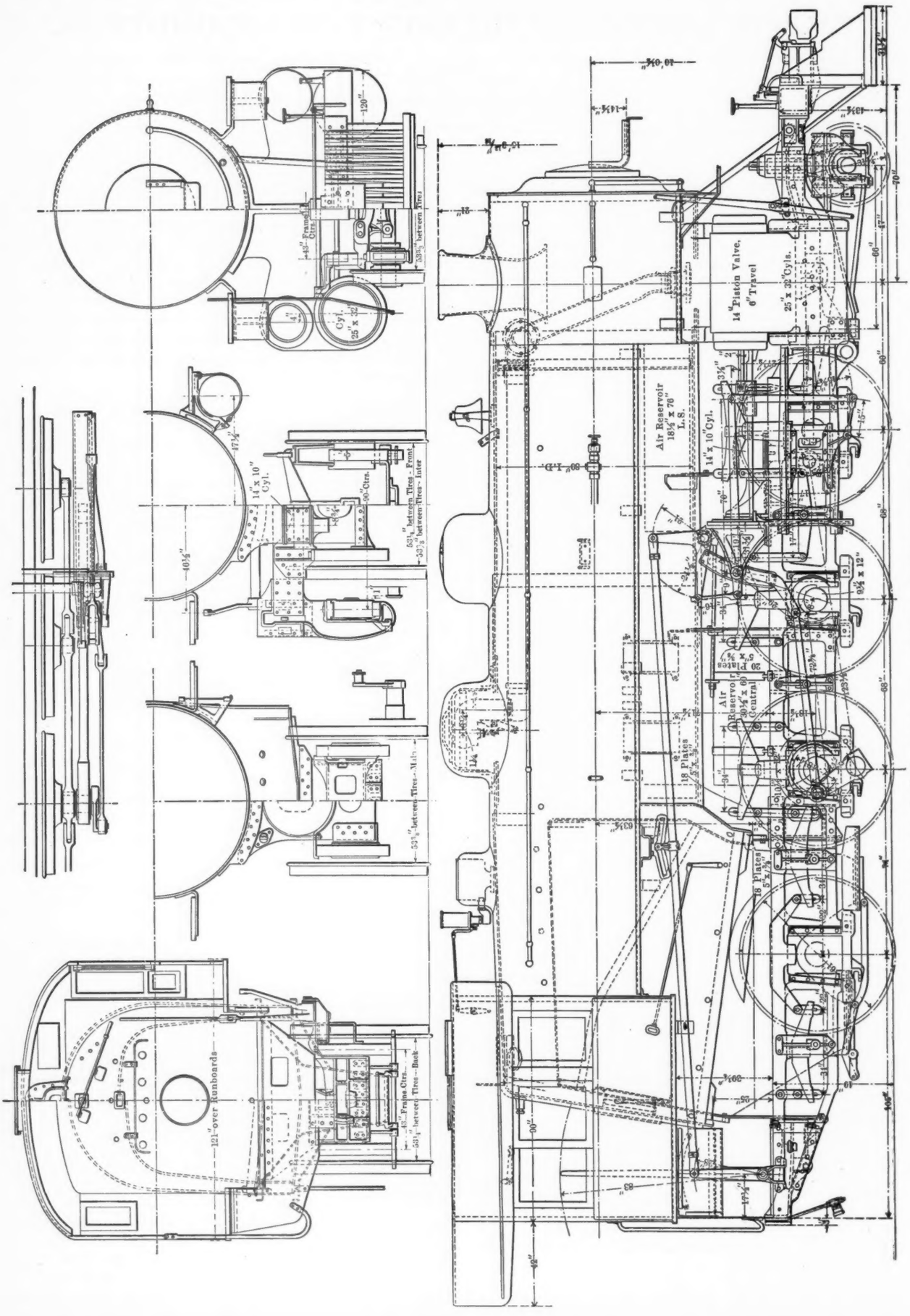

R & L
L.S. only
443- 2" Tubes Holes drilled 2" Dia.
70¼" Inside Firebox
443 Tubes, 2" Dia. Holes drilled 2 5/16" Spaces
Tubes marked thus + to be Beaded.
Holes shown thus ■ for Long Stays.


1" Rivets 3¼" Pitch
40- 1" Rivets in each Row.
145¼"
96" Rivets
93" Rivets
76- 1¾" Rivets in each Row
55½" Rivets
60" Dia. x ¾" Liner
Five Rows of Radial Stays from the Front to have Hammered Heads. Back of the Fifth Row, Six Center Rows are to be Button Heads and the Balance Hammered Heads.
182" (15'-2") over Tube Sheets
¾" Liner
6" x 6" x ⅝" Angle Iron
1" Stay Bolts
⅞" Stay Bolts
109⅜" Inside Firebox
Detail of Firebox Corrugations

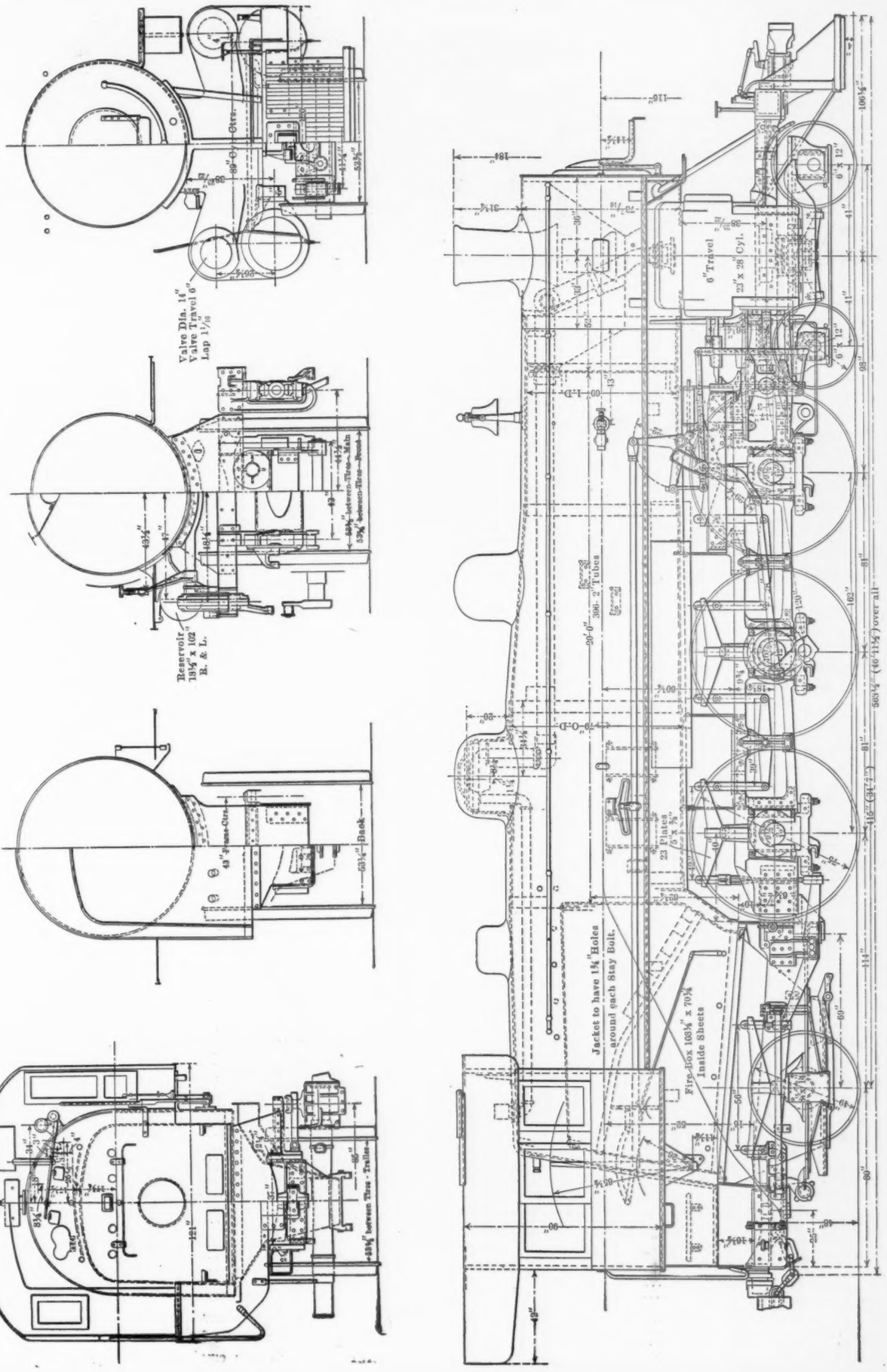
BOILER FOR CONSOLIDATION LOCOMOTIVE—CHICAGO & NORTHWESTERN RAILWAY.

A type of fire box that has been in service on this road for four or five years, with excellent results, has been applied to both types. This is of the corrugated side sheet type and was fully illustrated and described in the June, 1907, issue mentioned above. These side sheets are known by the name of Cour-Castle; the O'Connor large radius fire door flange is also used.

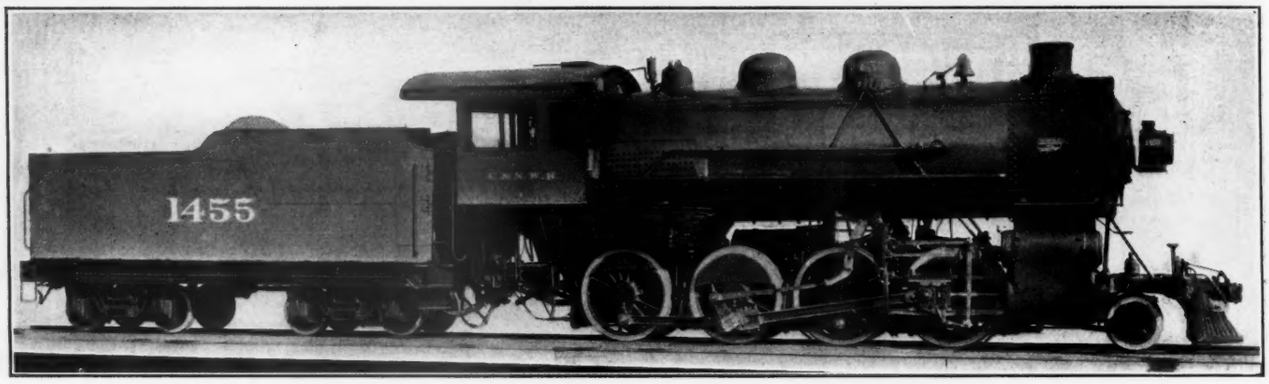
* See AMERICAN ENGINEER, June, 1907, page 247.



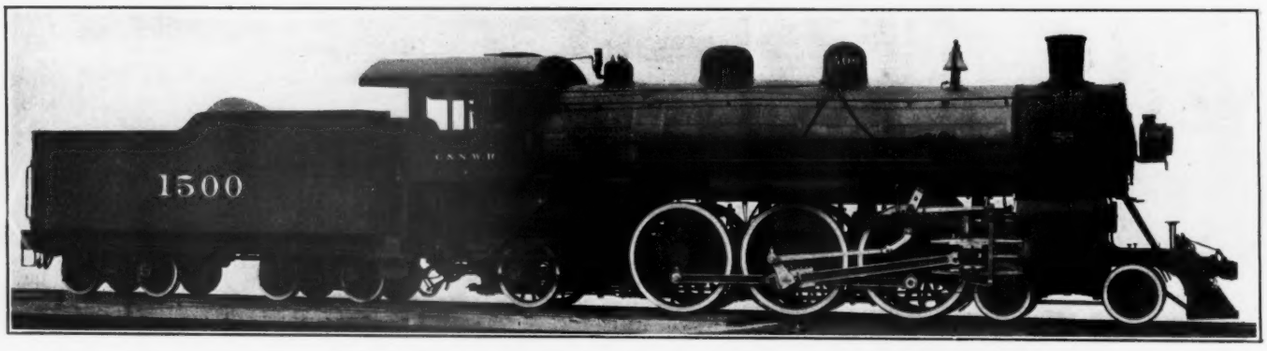

CONSOLIDATION (2-8-0) LOCOMOTIVE—CHICAGO & NORTHWESTERN RAILWAY.




PACIFIC TYPE (4-6-2) LOCOMOTIVE FOR THE CHICAGO & NORTHWESTERN RAILWAY.




CONSOLIDATION LOCOMOTIVE—CHICAGO & NORTHWESTERN RAILWAY.




PACIFIC TYPE LOCOMOTIVE—CHICAGO & NORTHWESTERN RAILWAY.

The cast steel frames consist of the main frame 5½ in. wide with a single front rail cast integral with it and a separate slab section 2½ in. wide at the rear for the trailing truck. The slab section is fitted into a recess at the back end of the rear frame, making a very strong and rigid splice.

Three-quarter inch bushings are fitted in the cylinders. The Walschaert valve gear follows the builders' latest pratice in the application to the Pacific type locomotive and is clearly shown in the illustrations. The frame bracing has been given very close study, the location and arrangement of the cross ties also being clearly shown in the illustration.

A trailing truck of the outside bearing radial type, the same as was applied to the Alton engine mentioned above, is used. This design was fully illustrated and described on page 269 of the July, 1909, issue of this journal. It eliminates the use of the outside supplementary frames, thereby simplifying the construction and effecting a considerable reduction in weight.

The consolidation locomotives have a total weight of 232,000 lbs., of which 88.3 per cent. is carried on the driving wheels.

One of the most interesting features of this design lies in the use of an unusually low boiler pressure with saturated steam. The pressure is but 170 lbs. and 25x32 in. cylinders are employed. These were very carefully and thoroughly lagged in order to reduce, as far as possible, cylinder condensation that would otherwise be excessive.

Fourteen inch piston valves are also used on these locomotives, being actuated by the Walschaert valve gear. Five inch cast steel frames with a single integral front rail are employed.

The illustrations show the general construction and also the details of the large boiler, of the straight top radial stayed type.

The general dimensions, weights and ratios are given in the following table:

| GENERAL DATA. | | |
|---|---|---|
| Type | 4-6-2 | 2-8-0 |
| Gauge | 4 ft. 8½ in. | 4 ft. 8½ in. |
| Service | Pass. | Frgt. |
| Fuel | Bit. Coal | Bit. Coal |
| Tractive effort | 31,900 lbs. | 47,500 lbs. |
| Weight in working order | 245,000 lbs. | 232,000 lbs. |
| Weight on drivers | 151,000 lbs. | 205,000 lbs. |
| Weight of engine and tender in working order | 399,100 lbs. | 382,900 lbs. |
| Wheel base, driving | 13 ft. 6 in. | 17 ft. 6 in. |
| Wheel base, total | 84 ft. 7 in. | 26 ft. 5 in. |
| Wheel base, engine and tender | 66 ft. 10½ in. | 60 ft. 9½ in. |
| **RATIOS.** | | |
| Weight on drivers ÷ tractive effort | 4.73 | 4.30 |
| Total weight ÷ tractive effort | 7.68 | 4.88 |
| Tractive effort × diam. drivers ÷ heating surface | 548.00 | 780.00 |
| Total heating surface ÷ grate area | 82.40 | 70.40 |
| Firebox heating surface ÷ total heating surface, % | 4.79 | 5.00 |
| Weight on drivers ÷ total heating surface | 34.80 | 53.90 |
| Total weight ÷ total heating surface | 56.20 | 62.30 |
| Volume both cylinders, cu. ft. | 13.28 | 18.16 |
| Total heating surface ÷ vol. cylinders | 328.00 | 204.00 |
| Grate area ÷ vol. cylinders | 3.99 | 2.90 |
| **CYLINDERS.** | | |
| Kind | Simple | Simple |
| Diameter and stroke | 23 x 28 in. | 25 x 32 in. |
| **VALVES.** | | |
| Kind | Piston | Piston |
| Diameter | 14 in. | 14 in. |
| Greatest travel | 6 in. | 6 in. |
| Outside lap | 1 1/16 in. | 1 in. |
| Inside clearance | 3/16 in. | 0 in. |
| Lead, constant | ¼ in. | 3/16 in. |
| **WHEELS.** | | |
| Driving, diameter over tires | 75 in. | 61 in. |
| Driving, thickness of tires | 3½ in. | 3½ in. |
| Driving journals, main, diam. and length | 10½ x 12 in. | 10½ x 12 in. |
| Driving journals, others, diam. and length | 9½ x 12 in. | 9½ x 12 in. |
| Engine truck wheels, diameter | 37¼ in. | 31¼ in. |
| Engine truck, journals | 6 x 12 in. | 6 x 12 in. |
| Trailing truck wheels, diameter | 49 in. | |
| Trailing truck, journals | 8 x 14 in. | |
| **BOILER.** | | |
| Style | E. W. T. | Str. |
| Working pressure | 190 lbs. | 170 lbs. |
| Outside diameter of first ring | 70 5/16 in. | 81½ in. |
| Firebox, length and width | 108⅜ x 70¼ in. | 108⅜ x 70¼ in. |
| Firebox plates, thickness | ⅜ & ½ in. | ⅜ & ½ in. |
| Firebox, water space | 4½ in. | 4½ in. |
| Tubes, number and outside diameter | 396—2 in. | 443—2 in. |
| Tubes, length | 20 ft. | 15 ft. 2 in. |
| Heating surface, tubes | 4,130 sq. ft. | 3,499 sq. ft. |
| Heating surface, firebox | 236 sq. ft. | 214 sq. ft. |
| Heating surface, total | 4,366 sq. ft. | 3,713 sq. ft. |
| Grate area | 53 sq. ft. | 52.7 sq. ft. |
| Smokestack, diameter | 19 in. | 20 in. |
| Smokestack, height above rail | 184 in. | 183 13/16 in. |
| Center of boiler above rail | 116 in. | 120½ in. |
| **TENDER.** | | |
| Tank | "U" | "U" |
| Frame | 13 in Chan. | 13 in. Chan. |
| Wheels, diameter | 37¼ in. | 34¼ in. |
| Journals, diameter and length | 5½ x 10 in. | 5½ x 10 in. |
| Water capacity | 7,500 gals. | 7,500 gals. |
| Coal capacity | 13 tons | 12 tons |

FIRES ON THE PENNSYLVANIA.—The annual report of the insurance department of the Pennsylvania Railroad System shows that the company's own employees extinguished 321 fires during 1909. These fires occurrred on property valued at more than $9,000,000, yet the loss amounted to only about $20,000.

# A GENERAL LOCOMOTIVE INSPECTION

## AN ACCOUNT OF THE METHOD OF PROCEDURE, SOME OF THE RESULTS AND THE CONCLUSIONS FOLLOWING A DETAILED INDIVIDUAL INSPECTION OF OVER FIFTEEN HUNDRED LOCOMOTIVES OF ALL TYPES AND SIZES.

By R. H. Rogers.

IN THREE PARTS—PART 3—INFERENCES AND CONCLUSIONS.

From a broad viewpoint it must be reluctantly asserted that locomotives are seldom uniformly maintained, even on the several divisions of any particular railroad. This criticism need not apply to the boilers of these engines, because uniformity does certainly exist in that quarter, not only on the individual railroads, but between railroads as a whole, and largely because legislation in certain States dictates tests and repairs as a compulsory procedure. Such refinement, however, has not been reached, nor is it desirable or necessary in connection with running gear and machinery, so dependence must be placed by the motive power management on the supervision and vigilance of the various divisions to keep these in proper condition.

The tabulated summary of the inspection of twelve divisions of a railroad, presented in the preceding article,* strikingly illustrates the great latitude which exists, no matter how the general situation may be hedged about with standard practises and special instructions. It shows clearly that these latter are not generally efficacious, although it must be admitted that there are few logical reasons why they should not be so, and the influence of personality is found to intrude here just as forcibly as in the conduct of private business enterprises.

Standard practises, which are never adopted until criticised by every master mechanic interested, may be presumed to achieve the same results on each and every division of a railroad, waiving, of course, the slight effect of varying service requirements, but nevertheless these articles have made it plainly apparent that such is not the case, and to establish the why and wherefore of the latter it is necessary to confine direct to the division at fault.

In view of the fact that all divisions are intended to be governed by the same rules the differences exhibited between existing conditions may arise (1) from insufficient appropriation or shop resources, or lack of ability to handle what is provided; (2) weakness in the local organization, which leaves its impress in one or more predominating detrimental conditions; (3) the human factor of fallibility on the part of the master mechanic in failing to view these latter in their true importance; (4) lack of sympathy with all or a portion of the standard practises, designed, of course, for the general good.

In the consideration last month of the five items in locomotive maintenance which apparently give the most trouble to hold in even reasonable check, these were defined as practically uncontrollable, that is, from a roundhouse standpoint at least, therefore the article largely confined to suggestions for back shop remedies, which it is believed would go far toward improving the conditions mentioned, no matter where located.

A similar review, however, of the above outlined associated features must necessarily be approached with hesitancy, because in their consideration it is not so easy to be convincing as in the former presentation of self-evident mechanical truths. Still the writer believes that some comment on the causes which he assigned for differences in existing conditions may not lack interest, although it is realized that his views may be as easily attacked as approved.

### THE MONTHLY APPROPRIATION.

This plan for financing a division is open to equal praise and censure. It is commendable in the abstract, as it implies the assurance that the head of the division will live up to its provisions, provided that the wish to keep his job is paramount, and thus discipline and economy are served through the same instrument. It is a mean proposition, nevertheless, and strikingly uncharitable as well, because it never reckons of varying conditions which any one month can exhibit over its predecessor. This statement must necessarily appear bold and questionable, but the writer well recalls three roads with which he has been associated where the monthly allotment actually remained at a fixed figure for no less than three years.

Let us consider what changes took place in motive power procedure and requirements on at least one of these three roads in that interval, and it will be readily appreciated that its master mechanics were placed at a disadvantage. These changes in requirements means, of course, betterments, and to meet these satisfactorily insures that more money must be spent. In the first of these three years an engine might be adequately put through general repairs for $1,100, but standardization and the application of new standards, which marked the ensuing two years, easily raised this total cost to $1,500. Still the appropriation remained the same, and as the standards *must* be embodied something had to be slighted in order to come "out on the month." The following citation may be of interest as illustrative of this point. It shows what was expected at the end of the third year for the same money, where not a single one of the items prevailed at the incipiency of the first year.

Driving axles were previously permitted to run below the limit, whereas the new dictation necessitated their renewal if worn ¼ in. below nominal size. Driving wheel centers with cracks, formerly banded, must now be renewed in the instance of general repairs. Loose driving box brasses now to be renewed, where shimming was formerly countenanced. The application of tire retaining screws or bolts—an absolute requirement in the instance of all passenger engines. Driving box flanges to be planed taper to relieve the shoe and wedge flanges. Piston heads when worn 1/16 in. below the diameter of the cylinder to be renewed when formerly 3/16 in. was the condemning limit. All engines as they go through the shop to have counterbalances weighed up, and if necessary corrected. Hopper ash pans to be applied, replacing flat pans, in accordance with federal laws.

These are some of the items on the road in question which went to increase the cost of classified repairs, without five cents more being allowed on the monthly appropriation, and are far from representing the entire scope of the additional outlay imposed. For instance, at that time there was in vogue a standard inspection system of safety appliances, necessitating that the gauge cocks and water glass cocks be removed from the boiler and cleaned on the occasion of each washout; the cylinder packing was also supposed to be examined at the same time, and the drawbar and drawbar pins removed and annealed. The muslin flags were replaced in this period by metal flags, which latter each shop was supposed to get out for its own engines, and the adjustment of wedges and keying up of rods, formerly undertaken by the engineers, devolved on the shop through the provisions in a new agreement secured by the engineers that they would not be called upon to do this work.

There is no doubt but that some of the above operations had been performed in several shops on the road in mind, but they

* See American Engineer, May, 1910, page 181, and June, 1910, page 215.

were not mandatory, being largely at the discretion of the gang foremen. The moment, however, that they became absolute requisites it was necessary to deputize men to perform them, and not one single boy can be added in classified repairs without increased cost.

These new requirements, of course, came gradually during the three years, and the master mechanics cheerfully assumed them without protest, or properly, without request for additional appropriation to meet them, whereas the writer is confident that had any one of these master mechanics summed up and presented the items which entered into increased costs of classified repairs, as has been done here, an increased appropriation would have been forthcoming.

The road to which reference is now being made worked its various divisions on the lump appropriation plan; that is, the apportionment of the appropriation was made by the master mechanic for his different departments, without interference so long as the lump sum was not exceeded. In consequence when the back shop costs increased from 10 to 30 per cent., from the causes given, this amount must necessarily be secured from other shops under that jurisdiction. As the back shop, machine shop and roundhouse are the principal integral elements in an ordinary division terminal the two latter must of course bear their proportion of this additional burden. Naturally the roundhouse, through the mere exercise of common sense, which dictates that it should be left alone, would be the last to feel the retrenchment, but finally it goes on eight hours, with all the attendant grief which the reduction of working time on running repairs always implies.

With all these things in mind it would certainly appear that on roads where many betterments are constantly being made to engines receiving thorough repairs that the lump appropriation plan should give way to the single allotment system, in which the total amount for the month is already apportioned by the superintendent of motive power before the master mechanic is credited with it. It is only fair that the master mechanic should receive an additional amount to cover the cost of betterments, but it is also fair to the management that it should be spent only in the department where the betterments are effected. No additional clerical work need be entailed through this procedure as accounts are now generally returned for each separate department under the lump appropriation plan.

The latter, with the intimation which is usually forthcoming that under no circumstances must it be exceeded, is in many cases so productive of anxiety and uneasiness that the master mechanic is interfered with taking the practical interest in his shops which he must feel to get the results. His time, which should properly be spent in devising ways and means, and in combating the obnoxious features which his division exhibits, is devoted to calculations as to whether he has come out "even on the day," or is "in a hole on the day." It is wrong to burden a position always associated with so much harassing detail with this additional worry over the possible expenditure of one hundred dollars more than his appropriation.

Monthly conditions are too variable to allow any fixed amount, and to make the same absolute. Sometimes so delicate is the balance with the money at hand that an insignificant wreck, necessitating eight or ten hours overtime for the wrecking crew, will disturb it to the extent that the shop is behind on the day, and the deficiency must be supplied from the next.

The writer believes that in the long run affairs in general are better served through a tacit understanding that an approximate sum will be spent each month. In any old established shop it is comparatively easy to hit on a suitable amount for a basis, and although the master mechanic understands that it is the desire of the management that this total be approximated every month, he knows also that it is flexible to a certain degree, and that harsh criticism will not follow a slightly increased expenditure provided that a sufficient reason be given. The writer while master mechanic for quite a long time on a prominent eastern railroad found this arrangement to work to a charm, and with a minimum of personal worry.

The amount usually expended in the principal shop under his jurisdiction, as nearly as can be recalled now, was $4,500 per week, and in three years there was little variation from this in week to week. When it was exceeded there was a good and sufficient reason, and the management of that road was sufficiently broad-gauged to honor the payroll increase without question. This was an enviable condition of affairs when contrasted with the tight policy prevailing on many other railroads in the form of a binding appropriation which does not reckon of the unusual or the unexpected when it is allowed, and may serve to partially, at least, account for the excellent condition of the rolling stock on the road which the writer has in mind.

This sub-division of the present article was inspired largely because that preceding somewhat unsparingly condemned the neglect or lagging conception of requirements, which countenances the presence on a division of excessive end play, unduly sharp flanges, poor shoes and wedges, etc., and it was thought consistent after this arraignment to comment on the other and more subtle factors which influence locomotive deterioration. Certainly the appropriation feature which has been dwelt upon herein is one of much prominence in this connection. If the appropriation is not adequate, and unfortunately in many cases it is not, this fact affords the opportunity to evade responsibility even for conditions on which the appropriation had little or no direct bearing.

It is not recommended by any means that this practically universal plan be dispensed with, but the writer believes that it should be modified and made more elastic in its provisions. Of course, in the instance of a struggling road, making both ends meet by the exercise of the most stringent economy, the situation had no doubt best be left alone, but the procedure as now evinced in many quarters is inconsistent with the earning capacity of great railroads, and much of it embodies a distinct menace to the proper up-keep of their locomotives.

### SHOP ORGANIZATION.

In the conduct of this particular feature there is largely in evidence the desire, if not the actual practise, to maintain a standard organization for all shops under the jurisdiction. From the standpoint of comparative accounting nothing can be offered in objection to this procedure, so far as the accumulation of impressive statistics is concerned, but unfortunately a close analysis of the latter shows them to be in the main fallacious because equal conditions do not exist between divisions.

It was quite apparent to the writer while traveling over the A. B. C. railroad that the shop organization, or properly the roundhouse organization, which was unquestionably adequate as applied to the H division, was nevertheless an absurdity on the F division. Conditions between these two divisions were utterly dissimilar. One included a thirty stall passenger roundhouse as well as a thirty stall freight house, with the resources of a large back shop and all the accompanying detail to draw upon, whereas the other had nothing but a five stall roundhouse, with a machine shop annex and no back shop. Still this latter division was supposed to conform at least to the outline of what prevailed on its neighbor, and a cumbersome manipulation of work resulted inimical to successful locomotive maintenance.

The fundamental idea of the standard organization may be all right, but the detail application is impracticable. Some of the provisions of standard shop practises and standard organization descend into absurdities when the attempt is made to universally apply them. Furthermore the demands imposed by the faithful adherence to standard practises are not adequately provided for in the standard organization, except possibly in spots.

For instance, the standard practises might call for the removal and annealing of all draw bars and draw bar pins on the occasion of each boiler wash, or the removal of the front cylinder heads and examination of the cylinder packing at the same time. With the very large force necessary to keep business going on the H division both of these would be possible, but practically impossible on the F division, with a force limited to five machinists and one small blacksmith fire, the latter solely for emergency work.

The instructions, however, governing these things are issued to all master mechanics without exception, and although common sense would dictate to the master mechanic of the F division that their observance could hardly be expected to be as binding on him as on his fellows with greater resources, still he realizes that nothing in the advices he has suggests anything of the kind. To avoid censure he makes a bluff at compliance, and it is simply time thrown away which might a thousand times be better applied to the correction of something evident and not chimerical.

For some unexplained reason roundhouse organization is lamentably weak at best, irrespective of what road or section of the country may be under consideration, and the imposition through standards of impossibilities does not tend to materially improve the prevailing conditions mentioned in the preceding article. An unbiased analysis of conditions anywhere would reveal that under the most favorable auspices merely sufficient machinists and boilermakers are allowed to do the routine work, with scarcely any reckoning on emergencies.

The standard organization, as generally constituted, specializes these men, particularly the former. There is a cab man, who packs the cocks, removes and applies injectors and tests the steam gauges when required; a valve man who looks after the valve setting, and often that alone; a shoe and wedge man, charged with the maintenance of those parts on engines in service; a packing man, to care for the metallic valve stem and piston rod packing; a steam pipe and exhaust man, for whatever repairs may be required in that line, and a spring man who contends with the removal and application of all driving and engine truck springs. In addition to these specialists there may be one or two in reserve for all around work on running repairs.

No matter what may be advanced for this system the writer claims that it will never result in a well balanced roundhouse organization All of these men cannot be occupied simultaneously. Many minutes in each hour are wasted, if not hours in the day, while they are waiting for something to turn up in their particular line, and the attitude of the roundhouse foreman, in many instances which have attracted attention, implies that it would be a breach of ethics to give those who are idle for the time being something to do out of their line.

It is through this allotment of labor and the evils attending it that the fallacy of attempting standard practises in the roundhouse is best illustrated. For instance, suppose that five engines are on hand for a boiler wash, and which according to the instructions must have their cylinder packing examined. This work must devolve on the one or two machinists mentioned who are employed on general running repairs, because it is not in the particular line of the specialists. About the time they get the cylinder heads off there will some real work show up for them elsewhere, but the foreman has had it impressed upon him in various staff meetings that this packing must be examined, so nine times out of ten he lets the real work go until the "next time," which, needless to add, never comes.

The writer knows that during the time these heavy cylinder heads are laboriously handled and pistons pulled, in almost every instance, needlessly, many a set of guides could be closed, and many a knuckle pin or bushing renewed; work which really counts.

All such practises, of which this is merely mentioned as an illustration, are intended to anticipate trouble; to correct latent defects before they assume serious proportions, and are, of course, based on the English idea of a "shed day," say once a week, for each locomotive, in which it is intended to perform the requisite amount of work to keep it going until the next shed day, thus minimizing the actual running repairs. Unfortunately through absolutely different conditions this country cannot reach the refinement which the railroads of the United Kingdom have attained in handling the question of locomotive repairs, and any imitation without a complete reorganization, which of course being untenable, simply does more harm than good.

The thought which occurs in this connection is that the reason locomotives in general were so much better maintained some twenty years ago is because the master mechanics had more latitude. In those days it was largely the case of one man dominating his local situation, and now the situation and the requirements often dominate the man. There is nothing mysterious or unsolvable about the wear of a locomotive engine, and the writer is confident that men sufficiently skilled in their trade to be made master mechanics, if left with reasonable latitude, can be depended upon to adequately maintain it. If each master mechanic were allowed to organize his own shop forces he would simply do what needs to be done, and in a few words this is the whole story.

### HUMAN FALLIBILITY IN SUPERVISION.

In this consideration the above sub-head is intended to refer to the judgment of the master mechanic, or his immediate responsible subordinate, concerning what defects can be countenanced and what should be remedied forthwith. A brief previous mention has been made of the very great latitude which exists in the exercise of this judgment, and it is graphically portrayed in the tabulated summaries of the detrimental features which in the writer's opinion prevailed on the various divisions of the A. B. C. railroad at the time of the inspection. It is clearly apparent that in many quarters an exaggerated care was taken of relatively minor ends while vital items were palpably slighted.

A preponderance of pounding crossheads is recalled in connection with a certain division, and with little if anything else to criticise. The writer attempted to point out in his reports from that locality that this condition had reached a point where broken frames might even be traced to it. In view of the fact that this job can be so easily taken care of in running repairs, the whole situation simply resolves into neglect of this particular part. It was present in the territory of a thoroughly competent and conscientious master mechanic, but he failed to attach any importance to the yawning guide bars, and probably his foremen knew that he did not. This is mentioned merely as an illustration of what the writer has termed human fallibility as a factor in locomotive deterioration.

Some of this fallibility is in reality the riding of a pet and long cherished hobby to which the following curious reminiscence will attest. On a certain division the inspector was amazed to note that from ¾ inch to 1¼ inch slack had been purposely left between the engine and tender of all engines, and particularly new 4-6-2 passenger power. It was gravely argued that it was impracticable to take up all the slack, especially on long wheel base engines; that with ½ inch slack the chafing casting on the engine set tight against the wedge on the tender when passing around the curves leading into the roundhouse. In addition to this the master mechanic asserted that experiments had convinced him that considerable less tire wear was present with the slack allowed than when it was entirely taken up.

Perhaps needless to add this latter conclusion was entirely erroneous. It arose, no doubt, from the conjecture that with the wedge tight in rounding curves the tendency of the train is to draw the back flanges hard against the rail, whereas just the contrary effect is produced. A consolidation engine curving to the right has Nos. 2 and 3 flanges, right side, in contact with the low rail, and if any cutting is going to be done it will be in connection with Nos. 1 and 4, left side, which are grinding on the high or outer rail. It will appear, therefore, that the tight connection between engine and tender is a positive advantage in drawing the engine toward the lower rail, and in a measure freeing the only flanges which can cut—those running against the high rail.

The object of the adjustable wedge between the engine and tender, as the writer understands it, is to maintain an even tension on the draw bar pins, and to minimize the strains and metal fatigue which naturally follow to both draw bar and pins through a recurrence of shocks. Innumerable failures of these parts can be recalled by the writer on many roads with which he has been connected and in which the investigation showed conclusively resulted from excessive slack.

It is really astonishing that such an argument should be presented, but it is only one of many similar fallacies. They are unfortunate when they crop out on any division of any railroad

because divisions are independent units with the same shop and road force often working in that territory for generations; hence once inaugurated, they are liable to be perpetuated.

Another forcible illustration of mechanical error in judgment was in connection with the fit of driving boxes on a certain division. The writer noticed that they were always properly bored; that is, sufficiently high in the crown to permit a fit on the center line of the axle. This was eminently correct, had they stopped there, but the next singular procedure was to take the box to a slotter and remove about ⅛ inch of metal back from the center line of the fit, affecting in all about 1 inch of the fit at the latter's most vital point of contact with the journal.

This extraordinary operation was explained by the master mechanic in that it permitted the grease passing through the perforated plate of the cellar lubricator to come into contact with more area of journal, and that it had been a local practise in that shop since the former box packing had been supplanted by grease.

Through following this unfortunate practise these engines had been leaving that shop from general repairs at the rate of five or six per month for quite a long period, and perhaps needless to add, with a grave internal disturbing force in the shape of box pound from the very day they left the shop. It became quite easy to trace the result through its subsequent ramifications in pounding and loose rod bushings and the utter impossibility to maintain the knuckle pins in anything like an adequate condition. It simply illustrates how an unfortunate theory can be foisted on a shop and remain there.

It is quite common on any railroad to see a valve seat and the valve simply planed, boxed up in the steam chest and the engine sent on her way, and in the very next shop the valve will be put down to a scraped and spotted bearing. In the first shop the driving boxes will be spotted to a fit; in the second they will be bored large enough to go on the journal and the wheel raised without even looking at the fit. The master mechanic in No. 1 shop will raise his engines off the engine truck center casting once in a while and dope the casting, but such a procedure is considered unnecessary in No. 2 shop, in fact, unknown. No. 3 shop will impose any number of penalties on its workmen if motion work pins are applied without being thoroughly case-hardened, while No. 4 shop displays considerable laxity in this regard, often slipping them in direct from the lathe.

This variation in ideas naturally introduces the concluding consideration of this series—the value of standard shop practises in securing uniform conditions.

### VALUATION OF STANDARD PRACTISES.

The valuation is, in fact, to be considered more than the value, the latter being, of course, admitted, otherwise the practises would not have been introduced. If these latter do not secure the results for which they were devised, they are not approached in the proper spirit by those charged with their administration. These are rather positive expressions, but the writer's experience leads him to no other conclusion. A rather uncharitable view has been taken in this article of standard shop organization and some standard roundhouse operations, because the attempt is made to apply them under conditions too variable, but standard shop practises is a different matter and the writer is wholly in accord with the plan.

The general scheme for introducing the practises is for the office of the superintendent of motive power to send to each master mechanic or person interested a copy of the idea to be returned with a criticism. Should these returns indicate more approval than disapproval, the practise is, as a rule, adopted for the system at large. It is very seldom that general approval is requisite to secure the introduction of a practise. This is where the hitch occurs in what should be an ideal procedure.

Two or three master mechanics will always remain who have indicated disapproval, with their reasons, and hence they are not in sympathy with it. When the practise becomes standard they will lend only half-hearted acquiescence at best. It is an unfortunate condition and goes far to defeat the intent of the standard practises, but quite frequently the management is more to blame than the few refractory master mechanics in allowing some absurd practises to get into circulation.

There is no matter in connection with railroading which need be more carefully approached than a judicious selection of standard practises and in limiting these to cover the essentially vital features of locomotive maintenance. It is entirely wrong to overburden the idea with too many practises, and they should be halted at a point this side of taking the entire initiative away from the master mechanic or the back shop supervision.

The writer believes that the essential features to be embodied in standard shop practises should be the removal of piston rods, driving axles, crank pins, driving box brasses, engine truck axles and tender truck axles when worn to a certain limit, the latter, of course, to appear on the practise card covering the part. Standard clearances to be established between driving box end play faces and wheel hubs. Slide valves to be removed when flanges become reduced to less than ⅝ inch thick. The bore of cylinders not to be allowed to exceed the nominal diameter more than ⅝ inch before bushing is applied. Valve chamber bushings to be renewed when inside diameter is ⅛ inch greater than nominal diameter. Wearing plates to be placed over frames wherever application is possible to protect frames from chafing of spring hangers.

It is quite easy to secure the co-operation of any master mechanic in adhering to the above because they indicate common sense truths in which little difference of opinion is possible, but as has been said before, care should be observed to avoid too much refinement. If the motive power management insists on and secures the fundamentals, it is a long way toward solving the problem of keeping up its locomotives, and can safely leave the elaboration to the various shops.

The writer has noticed shop practise cards on certain roads with which he could not agree, and they carried little appeal to the majority of the master mechanics. One, for instance: "Cylinders are to be rebored when out of round 1/16 inch or tapered 1/16 inch," and another, "All pistons of engines shall be renewed if 1/32 inch less than the diameter of cylinder." It may be that these cards were inspired by the idea to return the engine to as good shape as it was when new and to save fuel, but it is working things too fine, and such matters should be left to the discretion of the shops. The writer could not appreciate the consistency of seeking the ideal in that particular quarter with the side rods and motion work falling off the engine.

The proper and intelligent handling of standard practises to secure the results which will be forthcoming when so handled is to have a general shop inspector continuously on the road, and reporting direct to the superintendent of motive power, or highest mechanical officer. Provided that the proper man is secured, with the necessary combination of mechanical ability and tact, more can be done in two months to secure adherence to the standards than the superintendent of motive power's staff meetings in two years. When certain standards are found to be impracticable this man will soon know of it and cause them to be revised or abolished before much harm is done. This is because the master mechanics and others will criticise with much more freedom to him than to the highest official in the motive power department.

The special general inspection of the A. B. C. railroad which inspired these articles proved of great value. Faulty conditions automatically righted themselves in a most surprising manner when it is considered that the inspector was entirely without authority to order anyhing to be done. The moral effect of the inspection resulted in practically an instantaneous return to better things all along the line, and it may be after all that anticipation of this result was one of the prime factors to call it into being.

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STEEL PASSENGER CARS ON THE PENNSYLVANIA.—The Pennsylvania Railroad System has in service or on order nearly 2,000 all-steel passenger cars and it is announced that all future additions to the passenger equipment will be of all-steel construction. The Pullman Company is constructing a sufficient number of steel sleeping and parlor cars to equip the entire Pennsylvania System.

## NEW QUICK DUMPING ORE CAR.

PRESSED STEEL CAR COMPANY.

The transportation of ore from the mines to the docks at the Great Lakes and the unloading of the ore from the cars on the docks into the vessels for transportation over the lakes has always been an important part in the economical production of iron and steel, and the railroad companies engaged in this transportation have endeavored to own the best of cars and the best constructed docks in order to facilitate the unloading of the cars and the rapid loading of the vessel, all of which reduces the cost of transportation and the final cost of the ore at the furnaces.

The development of the cars to meet modern requirements on the lines of greater capacity and greater rapidity of unloading has, however, been considerably hampered by the permanent and expensive construction of the docks with pockets at regular short distances corresponding to the distances between the hatches on the vessels and in accordance with which the old equipment of wooden cars was built. This condition of circumstances cannot be changed without building new docks and changing the vessels, which is, of course, impracticable, as it would destroy interchangeability. This necessitates confining the general dimensions of new cars to the same length and to nearly the same width and height as the old equipment. Builders and designers of ore cars for this service were, therefore, not free agents in the construction of cars of the greatest efficiency, but were required to work in accordance with strict instructions, which, together with the comparatively limited knowledge available immediately following the introduction of steel cars, in regard to the strength and endurance of steel in car construction, naturally resulted in the building of cars which were not especially adapted to rapid unloading, or, in other words, were not self-clearing cars, requiring well-known features such as large unobstructed openings, steep slopes of hopper sheets and absence of sharp corners, similar to dumping cars and other apparatus used for different classes of ladings for many years.

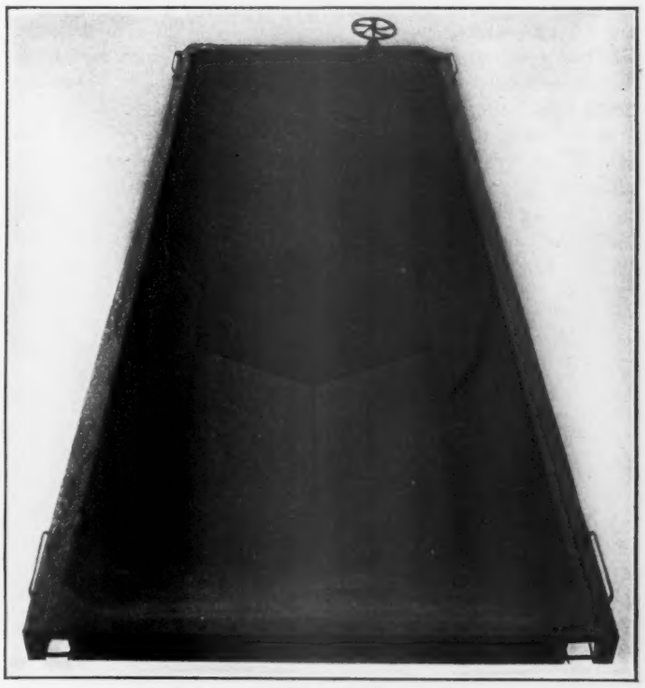
Recently the question of a reduction in time and labor required to unload the cars has become of more importance, principally through labor difficulties, but also to effect a more rapid loading of vessels as well as less detention of the cars. With this in view, the railroad companies have permitted a number of variations from the old standard dimensions which makes a more ideal construction of the cars possible.

The Pressed Steel Car Company has just completed a sample car representing a lot of 300 cars which it is building at its Chicago plant, the Western Steel Car & Foundry Co., for the Duluth & Iron Range, and the Duluth, Missaba & Northern Railroads, in the design of which is shown what can be done when hampering limitations are removed. This car, of which several views are presented, is all steel construction, and has the following general dimensions:

| | |
|---|---|
| Length over striking plates | 22 ft. 1 in. |
| Length inside of body | 18 ft. 1¾ in. |
| Width over side sheet | 8 ft. 7 in. |
| Width inside of body | 8 ft. 6½ in. |
| Height from rail to top of side | 9 ft. 6 in. |
| Height from rail to center of draw heads | 2 ft. 10½ in. |
| Length of door openings | 6 ft. 7¾ in. |
| Cubic contents, level | 686 cu. ft. |
| Cubic contents, ten inch average heap | 802 cu. ft. |
| Weight of car and trucks, empty | 32,700 lbs. |
| Rated capacity | 100,000 lbs. |
| Maximum capacity | 120,000 lbs. |
| Ratio of paying freight to total weight of car loaded | 78.6 per cent. |

VIEW OF QUICK DUMPING ORE CAR WITH POSITIVE DOOR OPERATING GEAR, SHOWING THE DOORS OPEN.

The car is of the single hopper center dumping type, and in order to make it self clearing and dispense with the necessity



TOP VIEW OF ORE CAR, DOORS CLOSED.

of poking the lading when unloading, the area of the bottom opening has been made very large, being about 50 sq. ft. and the slopes of the hopper sheets have been made 50° at the ends and 60° at the sides from the horizontal. These conditions were made possible without reducing materially the carrying capacity by increasing both the height and the width of the cars, reducing the wheel base of the trucks and spreading the trucks further apart from center to center. The door opening is closed by two doors hinged at the sides, which form part of the vertical sides, so that when opened, part of the sides, as well as the bottom, falls away from the load, thus making a large unobstructed opening, and reducing the chance of bridging to a minimum. The doors meet on the center line of the car and each are supported by two six inch channel bars, to which the door operating gear bars are attached.

One of the best features of this design is embodied in the door operating gear, which is arranged to be operated from either side of the car, and besides it is so arranged that when the doors are closed and the car is loaded, there is no strain on the winding gear proper; in other words, the supporting mechanism is self-locking and the load tends to keep the doors closed rather than to open them. This is accomplished by means of cranks which turn over a dead center into a position of rest. The doors are connected to the cranks by heavy rods with screw attachment for adjustment in place of chains; this prevents stretching and guarantees that the doors will stay tight, preventing leakage of ore in transit. Gears of this kind have given good service on coal cars, and have the further advantage of being positive so that when the doors are frozen and therefore cannot drop by gravity, they can be forced down by the connecting rods, which cannot be done with chain connections.

Another feature in connection with the door gear is a safety device absolutely positive in its action, and which will prevent the injury of the operator when opening the doors. To operate the doors the usual wrench is applied to the square end of the operating shaft; the crank arms referred to are revolved by means of block clutches having clearance of half a revolution, which permits the cranks to revolve for half a revolution, after having been brought over the dead center sufficiently to fully open the doors without moving the wrench in the operator's hands. After the doors have been opened the clutches are in proper position for closing the doors, there being no lost motion This arrangement is very simple, effective and readily understood. Every detail of the car has been worked out to secure the greatest economy in maintenance; the doors are stronger and more heavily braced than has ever been the practice in the past, which is essential to prevent distortion from steam shovel loading, under which usage it is particularly difficult to keep the doors tight and prevent leakage of ore.

In a recent test at the Clinton Furnaces at Pittsburgh the sample car was loaded with 100,300 pounds of wet ore and was unloaded by one man. The time consumed by the ore in leaving the car was eight seconds. Not a handful of the ore remained in the car, and no poking or hammering of the sides to loosen the ore was necessary, or resorted to, during the operation. The car was afterwards loaded with 68,000 pounds of steel punchings; the load being placed directly over the doors, and although this was a very severe test of the efficiency of the door gear, there was no sign of weakness or leakage.

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SHOP CARD INDEX SYSTEM.—"We have a system in our shop known as the card index system. We know each and every engine that is coming into the shop 30, 60 or 90 days in advance. Each foreman consults it and sees what is necessary and confers with the storekeeper so as to have his material on hand. Our shop was built in 1879 and is classed as a back number. Last month we took an engine in on April 11 and on the 19th we turned it out of the shop and it went into service on the 20th. It received a new set of driving boxes, shoes and wedges, and a firebox. We built an extra back end for the boiler. This we are doing for every class of engine we have on our system. This matter was lined up in one of our staff meetings with the storekeeper, and when the engine arrived on the pit each man had his part to look after. We had a flat car with a new firebox end on it, and it was placed behind the engine, one end of the car being empty. The other box was cut off on Tuesday morning, taken out to the turntable and pushed on the flat car which was turned, pushed back in and the other end put on the boiler. The jaws were faced on Monday and the shoes and wedges laid off on Tuesday. In order to get out of the way of the machinist, the blacksmith had to make two welds on the frames. We put him at that Monday evening. By planning and lining up these things we got wonderful results."—*F. C. Pickard at the General Foremen's Convention.*

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## TEST OF HOT WATER WASHOUT SYSTEM

The time consumed for the washing system at Macon, Ga., using the plant installed by the National Boiler Washing Co., Chicago, is as follows:

*Washing Wide Firebox Consolidation,* 1700 *Class,* 22 *x* 30 *in.*

| | |
|---|---|
| Coupling blow-off hose | 3 min. |
| Blowing off boiler, 50 lbs. steam, 2 gages water | 40 " |
| Removing 22 mud plugs | 15 " |
| Washing boiler | 20 " |
| Putting in mud plugs | 7 " |
| Filling boiler, 1 gage water | 14 " |
| Getting 50 lbs. steam | 30 " |
| Total, 2 hours and 9 minutes, or | 129 min. |

*Washing Narrow Firebox Consolidation,* 1030 *Class,* 21 *x* 32 *in.*

| | |
|---|---|
| Coupling hose | 3 min. |
| Blowing off boiler, 90 lbs. steam, 1 gage water | 42 " |
| Removing 18 mud plugs | 16 " |
| Washing boiler | 31 " |
| Putting in plugs | 12 " |
| Filling boiler | 7 " |
| Getting 50 lbs. steam | 34 " |
| Total, 2 hours and 25 minutes, or | 145 min. |

This class of boiler is the most difficult we have to wash.

*Small* 1500 *Class Engines,* 18 *x* 24 *in.*

| | |
|---|---|
| Coupling hose | 4 min. |
| Blowing off boiler | 18 " |
| Removing plugs | 11 " |
| Washing boiler | 9 " |
| Putting in plugs | 3 " |
| Filling boiler | 5 " |
| Getting 50 lbs. steam | 23 " |
| Total, 2 hours and 13 minutes, or | 73 min. |

Temperature—Washing, 150 deg.; filling, 200 deg.

*System of Washing in All Cases.*

1. Crown sheeet.
2. Flues at front end near checks.
3. Belly of boiler and bottom flues from front end of boiler toward firebox.
4. Back head, above and below fire door.
5. Sides.
6. Throat and back flue sheeets.
7. Arch pipes.

Washing water, 140 lbs. pressure; filling water, 180 lbs. pressure.

—*C. L. Dickert at the General Foremen's Convention.*

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*"A Study in Heat Transmission,"* by J. K. Clement and C. M. Garland, is issued as Bulletin No. 40 of the Engineering Experiment Station of the University of Illinois. This bulletin is for the technical reader and will be of interest to the student and physicist as well as the designer and operator of heating or cooling apparatus of any description. The results of the experiments apply directly to the problem of increased effectiveness of heating or cooling surfaces, which is a problem at the present moment engaging the attention of engineers. A large portion of the interest in the bulletin lies in the method of experimentation. The results show that the heat transmitted through the walls of a vessel in contact with water may be increased two or three times by increasing the velocity or rate of agitation of the water. Copies may be obtained gratis upon application to W. F. M. Goss, Director of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

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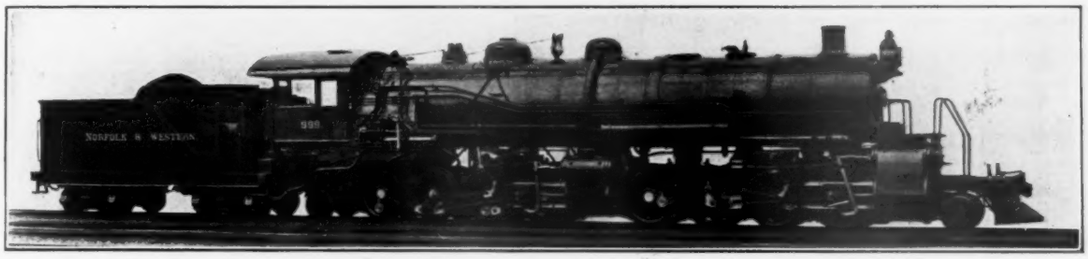
LUBRICATION TEST AT PURDUE UNIVERSITY.—By the addition of graphite to oil, there is a lower frictional resistance of the journal; the amount of oil required for a given service is reduced; a light or inferior quality of oil may be employed; water under favorable conditions may serve as a sufficient lubricant; a small amount of graphite only is required, as too much unduly thickens the oil and increases its internal friction due to vicosity. The benefits derived from the graphite persist long after its application has ceased.

# MALLET ARTICULATED LOCOMOTIVE 2-8-8-2 TYPE.

NORFOLK & WESTERN RY.

The Baldwin Locomotive Works has recently completed five heavy Mallet locomotives with the 2-8-8-2 wheel arrangement for the Norfolk & Western Ry. These engines are designated by the railway company as Class Y-1, and each is practically equivalent in capacity to two twelve-wheeled locomotives of class M-1. The latter engines are the standard on this road for heavy freight service, and weigh in working order 204,000 pounds.

The new engines will operate over grades of 2 per cent. combined with uncompensated curves of 8 degrees. The sharpest curves on the main line are of 12 degrees. The track is laid with 85 pound rails.



LOCOMOTIVE FOR SERVICE ON 2 PER CENT. GRADES WITH 8 DEGREE CURVES—NORFOLK AND WESTERY RY.

These engines are in many respects similar to Southern Pacific locomotives 4000 and 4001, which were built in the spring of 1909. They are lighter, however, and present various differences in details. The design has been worked out along lines adopted by the builders for heavy Mallet locomotives, while the details, where possible, accord with existing Norfolk & Western practice.

The boiler is of the straight topped, separable type, with a feed-water heater in the front section. The fire-box has a sloping back head, and the crown is stayed by radial bolts; while 472 flexible bolts are placed in the outside rows in the sides, back and throat. The barrel of the main boiler is composed of three rings, with sextuple riveted butt seams on the top center line. The seams are welded at the ends. The dome is on the forward ring, and the seam is strengthened by a large diamond shaped welt strip placed inside.

The water heater is traversed by 450 tubes, which are distributed over the entire cross section. Both injectors are placed on the right hand side in front of the cab, and they force water into the heater through a single check valve also placed on the right hand side. The heater is surmounted by a manhole, and the feed is discharged through a suitable fitting which is tapped into the manhole cover. The heated water enters the boiler proper through a single check valve, placed on the left side immediately back of the front tube sheet.

The arrangement of the steam piping is similar to that used on the Southern Pacific locomotives previously referred to. The high pressure exhaust is conveyed forward, through horizontal pipes, to the smoke-box, where it is passed through a Baldwin reheater. The spark arrester consists of a perforated plate, so located that all the products of combustion must pass through it before entering the stack.

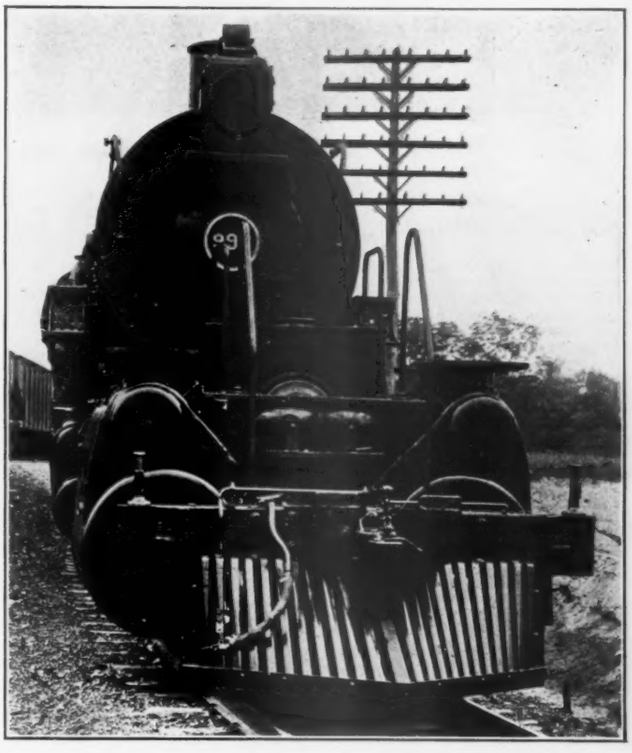
The steam distribution is controlled throughout by 15 inch piston valves, set with a lead of ¼ inch. The four valves are duplicates of one another, those controlling the high pressure distribution being arranged for inside admission, while the low pressure valves have outside admission. The ports and bridges are modified to suit. The valves are of cast iron with L-shaped packing rings sprung in. Walschaert motion is used, and the high and low pressure gears are controlled simultaneously by the Baldwin power reverse. The front and back reverse shafts are connected by a single reach rod placed on the center line.

The arrangement of the articulated connection and the method of securing the cylinders to the frames, accord with the regular practice of the builders for engines of this size. The frames are of cast steel, 5 inches in width, and of most substantial construction. The pedestal binders are lugged to the pedestals and held in place by three 1¼ inch bolts on each side.

The equalization is continuous throughout each group of wheels, trucks included. The front truck is center bearing and the rear truck side bearing.

The waist bearers which support the forward boiler section are of the usual design, and are both under load. The fire-box is carried on sliding bearers at the front and back.

The tender frame is composed of 15 inch channels for the center sills and 12 inch channels for the side sills. The bumpers are of oak. The frame is strongly braced, and the frame bolsters are built up of ½ inch steel plates and 4 x 3 inch angles. The frame is braced transversely, at mid-length, by two 8-inch channels. The trucks are of the arch-bar type, with I-beam bolsters,



FRONT VIEW OF NORFOLK AND WESTERN MALLET.

triple elliptic springs and rolled steel wheels. The lower spring seats are mounted on rollers, thus providing the equivalent of a swing truck. The tank is of the water bottom type.

These locomotives are far larger than any previously built for the Norfolk & Western Railway, but for Mallet engines their size is not unprecedented. The principal features embodied in their construction have been fully tried out on locomotives previously built, and satisfactory results may therefore be anticipated.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.

| | |
|---|---|
| Gauge | 4 ft. 8½ in. |
| Service | Freight |
| Fuel | Bit. coal |
| Tractive effort | 77,000 lbs. |
| Weight in working order, est. | 390,000 lbs. |
| Weight on drivers, est. | 360,000 lbs. |
| Weight on leading truck, est. | 15,000 lbs. |
| Weight on trailing truck, est. | 15,000 lbs. |
| Weight of engine and tender in working order, est. | 560,000 lbs. |
| Wheel base, driving | 40 ft. 3 in. |
| Wheel base, total | 55 ft. 6 in. |
| Wheel base, engine and tender | 83 ft. 3 in. |

RATIOS.

| | |
|---|---|
| Weight on drivers ÷ tractive effort | 4.67 |
| Total weight ÷ tractive effort | 5.06 |
| Tractive effort × diam. drivers ÷ heating surface | 730.00 |
| Total heating surface ÷ grate area | 78.50 |
| Tube heating surface ÷ firebox heating surface | 20.50 |
| Weight on drivers ÷ total heating surface | 61.00 |
| Total weight ÷ total heating surface | 66.00 |
| Volume both cylinders, cu. ft. | 23.05 |
| Total heating surface ÷ vol. cylinders | 256.00 |
| Grate area ÷ vol. cylinders | 3.26 |

CYLINDERS.

| | |
|---|---|
| Kind | Compound |
| Diameter | 24½ and 39 in. |
| Stroke | 30 in. |

VALVES.

| | |
|---|---|
| Kind | Piston |
| Diameter | 15 in. |
| Lead | ¼ in. |

WHEELS

| | |
|---|---|
| Driving, diameter over tires | 56 in. |
| Driving, thickness of tires | 3 in. |
| Driving journals, main, diameter and length | 10 x 12 in. |
| Driving journals, others, diameter and length | 9¼ x 12 in. |
| Engine truck wheels, diameter | 30 in. |
| Engine truck, journals | 6 x 10 in. |
| Trailing truck wheels, diameter | 30 in. |
| Trailing truck, journals | 6 x 10 in. |

BOILER.

| | |
|---|---|
| Style | Straight |
| Working pressure | 200 lbs. |
| Outside diameter of first ring | 80 in. |
| Firebox, length and width | 120⅛ x 90¼ in. |
| Firebox plates, thickness | ⅜ and ½ in. |
| Firebox, water space | F. 5½, S. & B. 5 in. |
| Tubes, number and outside diameter | 350—2¼ in. |
| Tubes, length | 21 ft. |
| Heating surface, tubes | 4,309 sq. ft. |
| Heating surface, firebox | 210 sq. ft. |
| Heating surface, feedwater heater | 1,389 sq. ft. |
| Heating surface, total | 5,908 sq. ft. |
| Reheater heating surface | 586 sq. ft. |
| Grate area | 75.2 sq. ft. |

TENDER.

| | |
|---|---|
| Water capacity | 9,000 gals. |
| Coal capacity | 14 tons |

## PAINT CAN STORAGE LOCKER

A locker for storing paint cans that are in daily use, as well as oils and other inflammable material, should be fireproof, capable of easy cleaning and sufficiently ventilated to prevent spontaneous combustion and so arranged that any can of oil or paint can be conveniently obtained without running any risk of tipping over other cans.

An arrangement which fills all of these conditions in an excellent manner has been installed at the Readville shops and is shown in the accompanying photograph. This consists of a platform slightly above the floor lever, covered with zinc plates and having a back about 30 in. high to which are hinged the covers that enclose the top and front of the locker. These covers are of sheet metal and are counterbalanced by weights on the cables passing over the pulleys seen projecting up from the back. They are provided with a small ventilator in the top and when closed make a locker that is sufficiently air tight to prevent rapid evaporation and drying of the paints, while still not being entirely unventilated. The locker here shown has three sections, and can, of course, be easily extended as required. In this are stored the cans of oils, paint cans that have been opened, brushes, etc.

VIEW SHOWING THE PAINT STORAGE LOCKER. THE COVERS ARE COUNTERBALANCED BY WEIGHTS AND HAVE VENTILATORS IN THE TOP. THE WHOLE LOCKER IS MADE OF SHEET STEEL

ELECTRIC LIGHTED TRAINS ON THE BURLINGTON.—All the through passenger trains of the Burlington are now electric lighted throughout, from locomotive to observation platform. Seventy-two complete trains and practically all the reserve passenger equipment of the entire Burlington system have been equipped, including locomotives, baggage cars, mail cars, coaches, chair cars, dining cars, sleeping cars and observation cars. No such extensive and costly improvement of coach lighting has been attempted before.

## AN IMPROVED LOCOMOTIVE CYLINDER AND FRAME ARRANGEMENT.

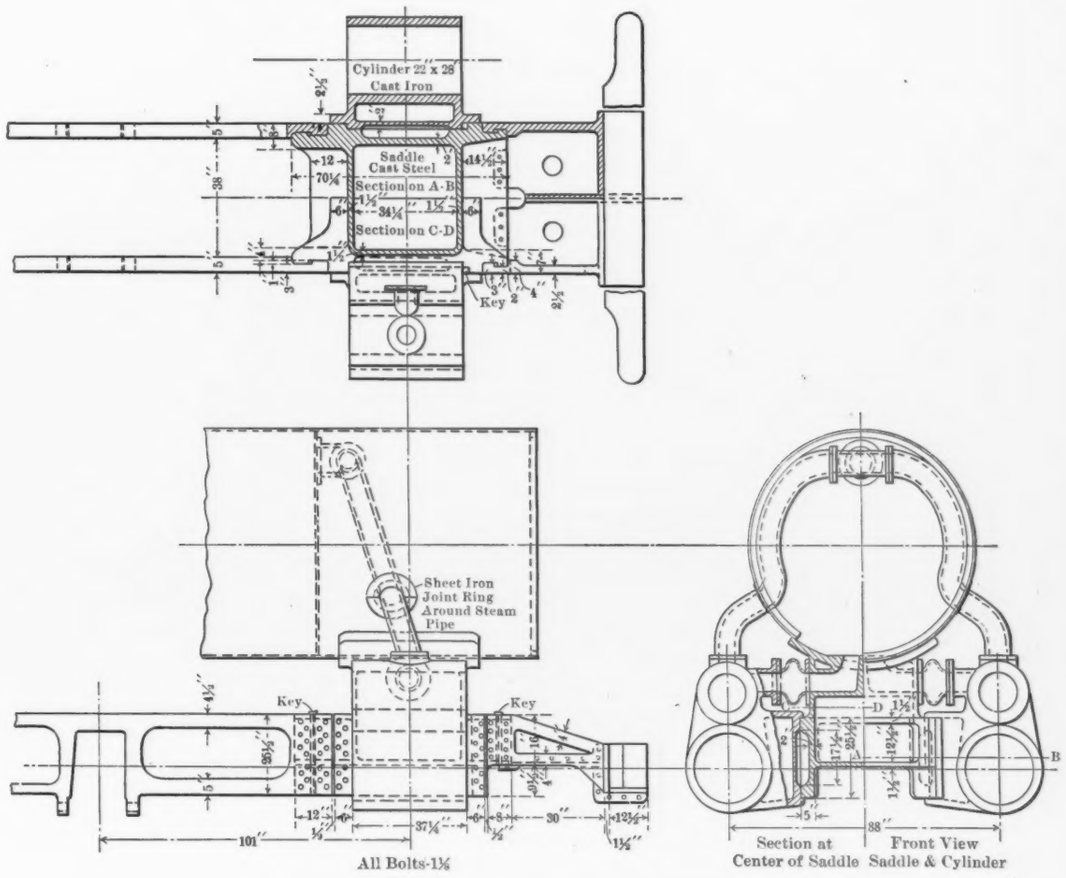
A cylinder and frame construction which permits the terminating of the frames back of the cylinders and increases the strength and stiffness at this point, as well as simplifying the whole casting, has been patented by O. N. Terry and J. G. Crawford.

The construction provides a cast steel saddle that includes flanges front and rear to which the frames are securely fastened. The arrangement shown in the illustration is where the cylinders are cast separate from the saddle, although the same idea can be applied with the usual combined cylinder and half saddle.

In the former case the saddle is of cast steel and contains the exhaust port only, this being a direct passage from the side of the saddle near the top directly to the exhaust pipe. The remainder of the casting is a shell with the necessary stiffening ribs and walls. The rear frame connections are arranged to cover the entire depth of the frame, the construction including a vertical key and horizontal bolts in the customary manner for rigid frame joints. A horizontal web at this point increases the stiffness. The same construction is provided at the front, the frames here probably being in the form of steel castings, including the deck plate. The cast iron cylinders are bolted and keyed to the saddle, the arrangement being for the steam pipes to enter the top of the valve chambers. In order to eliminate careful fitting a flexible joint is provided for the exhaust passage between the cylinder and saddle. This arrangement is clearly shown in the illustration. The steam pipes are continued outside of the front end just above the cylinder and enter the top in a manner somewhat similar to the usual construction on Mallet compounds at the high pressure cylinder.

With combined cylinders and half saddles the construction is very similar, with the exception that the exhaust passage is continued in the casting, the steam pipe connections being the same as those here illustrated. In this case it is recommended that the cylinder be of cast steel and provided with bushings for the pistons and valves.

The advantages of an arrangement of this kind in the matter of convenience of repairs, are readily apparent. The cylinders are easily removed without disturbing other parts in the vicinity; the front frames can be taken down quickly and the steam passages are much more direct and shorter and, in the case of the separable saddle, the cylinder castings are greatly simplified and cheapened.




FRAME AND CYLINDER CONNECTIONS FOR LOCOMOTIVE WITH SEPARATE SADDLE.

SCHOLARSHIPS FOR GRAND TRUNK EMPLOYEES.—The Grand Trunk Railway has announced that the company will give free, three scholarships, each covering four years, in the faculty of applied science of McGill University, Montreal, Que., to apprentices and other employees of the company under 21 years of age and to minor sons of employees. These scholarships will be awarded under competitive examinations. Scholarships will be granted for one year and be renewed from year to year, to cover the four years, provided the holder makes satisfactory progress. The holders of these scholarships will be required to serve the road as student apprentices during vacation periods, and, at the option of the company, for two years after completing the college course.

HIGH SPEED EXCURSION TRAIN.—On Saturday, May 21, the Michigan Central ran an excursion train of 12 cars, all well filled, from Windsor, Ont., to Falls View station, 224 miles, in 224 minutes; and, following this, another train of the same length made the same distance in seven minutes less; and both trains ran through without a stop. In making these fine runs the road had professional witnesses in large numbers. All of the passengers in both trains were members of the Brotherhood of Locomotive Engineers, who had been holding their biennial convention in Detroit.

# A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

## ARRANGED WITH RESPECT TO TOTAL WEIGHTS

### MALLET ARTICULATED COMPOUND LOCOMOTIVES

| TYPE | 2-8-8-2† | 0-8-8-0 | 2-8-8-2 | 2-8-8-2 | 0-8-8-0 | 2-6-8-0 | 4-4-6-2† | 2-6-6-2 | 2-6-6-2 | 2-6-6-2 | 2-6-6-2 | 0-6-6-0 | 2-6-6-0 | 2-8-8-2 | 0-6-6-0 | 2-6-6-2 | 2-6-6-2 | 0-6-6-0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME OF ROAD | A. T. & S. F. | D. & H. | N. P. | S. P. | Erie | G. N. | A. T. & S. F. | C. B. & Q. | G. N. | B. & A. | Mex. Cen. | B. & O. | V. R. R. | N. & W. | D. N. W. & P. | N. P. | G. N. | Can. Pac. |
| Road number or class | 1,700 | 1,600 | 4,000 | 4,000 | 2,600 | 1,959 | 1,300 | 4,100 | L-I | 1,249 | H | 2,400 | ..... | Y-I | 200 | 4,000 | ..... | 1900 |
| Builder | Bald. | Amer. | Bald. | Bald. | Amer. | Bald. | Bald. | Bald. | Bald. | Amer. | Bald. | Amer. | Amer. | Bald. | Amer. | Bald. | Bald. | Can. Pac. |
| When built | 1909 | 1910 | 1910 | 1909 | 1907 | 1909 | 1909 | 1909 | 1906 | 1910 | 1908 | 1904 | 1909 | 1910 | 1909 | 1909 | 1907 | 1909 |
| Tractive effort, lbs. | 108,300 | 105,000 | 94,640 | 94,640 | 94 800 | 82,000 | 62,850 | 70,500 | 71,600 | 66,600 | 71,600 | 70,000 | 70,800 | 77,000 | 74,130 | 57,760 | 57,760 | 57,400 |
| Weight, total, lbs. | 462,450 | 445,000 | 437,950 | 425,900 | 410 000 | 378,300 | 376,850 | 361.650 | 355.000 | 342,000 | 338,000 | 334,500 | 340,000 | 390,000 | 327,500 | 305,150 | 288,000 | 262.000 |
| Weight on drivers, lbs. | 412,350 | 445,000 | 403,800 | 394,150 | 410,000 | 359,600 | 268,400 | 304,500 | 316.000 | 296,500 | 300,000 | 334,500 | 312 000 | 360,000 | 327,500 | 262,350 | 250,000 | 262,000 |
| Weight on trucks, lbs. | 24,050 | ..... | 14,750 | 14,500 | ..... | 18,700 | 58,050 | 21,000 | 19,000 | ..... | 19,000 | ..... | 18,000 | 15 000 | ..... | 21,500 | 18,000 | ..... |
| Weight on trailer, lbs. | 26,050 | ..... | 15,400 | 17,250 | ..... | ..... | 50,400 | 36,150 | 20,000 | ..... | 19,000 | ..... | ..... | 15,000 | ..... | 21,300 | 20,000 | ..... |
| Weight, tender loaded, lbs. | 234 000 | 166,800 | 152,000 | 170,100 | 167,700 | 147,700 | 234,000 | 153,400 | 148,000 | 152,700 | 157,000 | 143,000 | 162,300 | 170,000 | 159,800 | 149,850 | 152,000 | 139,000 |
| Wheel base, driving, front group | 16′ 6″ | 14′ 9″ | 16′ 0″ | 15′ 0″ | 14′ 3″ | 10′ | 6′ 4″ | 11′ 6″ | 10′ | 10′ | 9′ 2″ | 10′ | 11′ | 15′ 6″ | 10′ | 11′ 2″ | 9′ 10″ | 10′ 4″ |
| Wheel base, driving, rear group | 16′ 6″ | 14′ 9″ | 16′ 0″ | 15′ 0″ | 14′ 3″ | 15′ | 12′ 8″ | 11′ 6″ | 10′ | 10′ | 9′ 2″ | 10′ | 11′ | 15′ 6″ | 10′ | 11′ 2″ | 9′ 10″ | 10′ 4″ |
| Wheel base, total engine | 59′ 10″ | 40′ 2″ | 56′ 7″ | 56′ 7″ | 39′ 2″ | 43′ 11″ | 51′ 11″ | 51′ 5″ | 44′ 10″ | 30′ 8¼″ | 44′ 2″ | 30′ 8″ | 39′ 11″ | 55′ 6″ | 30′ 8″ | 43′ 7″ | 43′ 7″ | 35′ 2″ |
| Wheel base, engine and tender | 98′ 0⅜″ | 75′ 7½″ | 82′ 7¾″ | 83′ 6″ | 70′ 5½″ | 76′ 2½″ | 94′ 5½″ | 83′ 2½″ | 73′ 2½″ | 74′ 8″ | 70′ 11″ | 64′ 7″ | 73′ 2 11/16″ | 83′ 3″ | 64′ 4″ | 70′ 10½″ | 72′ 0½″ | 60′ 7 ″ |
| Diameter of drivers | 63″ | 51″ | 57″ | 57″ | 51″ | 55″ | 73″ | 64″ | 55″ | 57″ | 55″ | 56″ | 54″ | 56″ | 55″ | 55″ | 55″ | 58″ |
| Cylinders, high pressure, diameter | 26″ | 26″ | 26″ | 26″ | 25″ | 23″ | 24″ | 23″ | 21½″ | 20½″ | 21½″ | 20″ | 22″ | 24½″ | 20½″ | 20″ | 20″ | 23¼″ |
| Cylinders, low pressure, diameter | 38″ | 41″ | 40″ | 40″ | 39″ | 35″ | 38″ | 35″ | 33″ | 33″ | 33″ | 32″ | 35″ | 39″ | 33″ | 31″ | 31″ | 34″ |
| Cylinders, stroke | 34″ | 28″ | 30″ | 30″ | 28″ | 32″ | 28″ | 32″ | 32″ | 32″ | 32″ | 32″ | 30″ | 30″ | 32″ | 30″ | 30″ | 26″ |
| Steam pressure, lbs. | 220 | 220 | 200 | 200 | 215 | 200 | 220 | 200 | 200 | 210 | 200 | 235 | 200 | 200 | 225 | 210 | 210 | 200 |
| Boiler, type | Str. | Conical | Str. | Str. | Str. | Belp. | Str. | Str. | Belp. | Str. | Str. | Str. | R. W. T. | Str. | Str. | Str. | Belp. | W. T. |
| Boiler, smallest diameter | 84″ | 90″ | 84″ | 84″ | 84″ | 84″ | 72″ | 78″ | 84″ | 83¾″ | 78″ | 84″ | 76″ | 80″ | 84″ | 74″ | 72″ | 57⅜″ |
| Boiler, height center | ..... | 120″ | ..... | 120″ | 120″ | ..... | 118″ | 114½″ | 120″ | 119½″ | ..... | 120″ | 116″ | ..... | 120″ | ..... | 116″ | 110⅝″ |
| Heating surface, tubes, sq. ft. | 4,766 | 6,276 | 4,941 | 4,941 | 4,971 | 3,038 | 3,275 | 2,708 | 5,473 | 5,291 | 4,311 | 5,380 | 4,842 | 4,309 | 5,035 | 3,816 | 3,708 | 2,605 |
| Heating surface, firebox, sq. ft. | 243 | 353 | 252 | 232 | 343 | 225 | 202 | 210 | 230 | 185 | 201 | 220 | 224 | 210 | 206 | 198 | 198 | 180 |
| Heating surface, feed heater, sq. ft | 1,665 | ..... | 1,220 | ..... | ..... | 1,797 | 1 279 | 2,172 | ..... | ..... | ..... | ..... | ..... | 1 389 | ..... | ..... | ..... | ..... |
| Heating surface, superheater, sq. ft. | 544 | ..... | ..... | 655 | ..... | 480 | 323 | 464 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 420 |
| Heating surface, reheater, sq. ft. | 1,201 | ..... | 655 | ..... | ..... | ..... | 798 | ..... | ..... | ..... | ..... | ..... | ..... | 586 | ..... | ..... | ..... | ..... |
| Heating surface, total,* sq. ft. | 6 674 | 6,629 | 6,413 | 5,173 | 5,314 | 5,060 | 4,756 | 5,090 | 5,703 | 5 476 | 4,512 | 5,600 | 5,066 | 5,908 | 5,241 | 4,014 | 3,906 | 2,785 |
| Grate area, sq. ft. | 70.9 | 100 | 84 | 68.4 | 100 | 78 | 52.5 | 63 | 78 | 56.5 | 61 | 72.2 | 57 | 75.2 | 72.2 | 53.4 | 53.4 | 58 |
| Firebox, length | 129⅝″ | 126½″ | 114″ | 126″ | 126½″ | 117″ | 119⅜″ | 120″ | 117″ | 108″ | 123½″ | 108⅛″ | 114″ | 120½″ | 108″ | 116⅛″ | 116½″ | 120″ |
| Firebox, width | 78⅜″ | 114″ | 96″ | 78¼″ | 114¼″ | 96″ | 63¼″ | 78½″ | 96″ | 75½″ | 71″ | 96¼″ | 72″ | 96¼″ | 96″ | 66¾″ | 66½″ | 69⅞″ |
| Fuel, kind | Oil | Bit. coal | Bit. coal | Oil | Bit. coal | Bit. coal | Oil. | Lignite | Bit. coal | Bit. coal | Oil | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal |
| Tubes, number | 387 | 446 | 401 | 401 | 404 | 275 | 294 | 218 | 441 | 410 | 350 | 436 | 390 | 350 | 409 | 310 | 301 | ** |
| Tubes, diameter | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¾″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | ** |
| Tubes, length | 21′ | 24′ | 21′ | 21′ | 21′ | 15′ | 19′ | 16′ 6″ | 21′ | 22′ | 21′ | 20′ 10″ | 21′ | 21′ | 21′ | 21′ | 21′ | ** |
| Tender, fuel capacity, tons | 4000 | 14 | 13 | 2,850 | 16 | 13 | 4,000 | 13 | 13 | 12 | 3,500 | 16 | 14 | 14 | 12 | 13 | 13 | 12 |
| Tender, water capacity, gallons | 12000 | 9,000 | 8,000 | 9,000 | 8,500 | 8,000 | 12,000 | 8,000 | 8,000 | 8,000 | 8,000 | 7,000 | 9,500 | 9,000 | 9,000 | 8,000 | 8,000 | 6,000 |
| Weight on drivers ÷ tractive effort | 3.78 | 4.23 | 4.26 | 4.18 | 4.32 | 4 38 | 4.27 | 4.33 | 4.40 | 4.45 | 4.20 | 4.75 | 4.41 | 4.67 | 4.40 | 4.56 | 4.34 | 4.57 |
| Weight, total ÷ tractive effort | 4.24 | 4.23 | 4.63 | 4.51 | 4.32 | 4.60 | 5.99 | 5.13 | 4.95 | 5.13 | 4.70 | 4.75 | 4.67 | 5.06 | 4.40 | 5.30 | 5.00 | 4.50 |
| T. E. × diam. drivers ÷ total H. S. | 1022. | 807.00 | 840.00 | 1040.00 | 910.00 | 894.00 | 965.00 | 886.00 | 690.00 | 693.00 | 873.00 | 700.00 | 753. | 730.00 | 780.00 | 785.00 | 813.00 | 1190.00 |
| Total heating surface ÷ grate area | 94.50 | 66.29 | 76.60 | 75.60 | 53.14 | 65.00 | 90.50 | 80.80 | 73.00 | 97.00 | 74.00 | 77.30 | 88.50 | 78.5 | 72.60 | 75.00 | 73.00 | 48.00 |
| Firebox H. S. ÷ total H. S., % | 3.65 | 5.31 | 3 90 | 4.50 | 6.46 | 4.45 | 4.25 | 4.13 | 4.13 | 3.40 | 4.45 | 3.92 | 4.42 | 3.55 | 3.90 | 4.94 | 5.05 | 6.46 |
| Weight on drivers ÷ total heating surface | 62 00 | 67.00 | 62.50 | 76.00 | 76.90 | 71.00 | 56.30 | 59.80 | 55.20 | 54.00 | 66.50 | 59.50 | 61.90 | 61.00 | 62.20 | 65.10 | 63.90 | 94.00 |
| Weight, total ÷ total heating surface | 69.40 | 67.00 | 68.00 | 82.50 | 76.90 | 75.00 | 79.20 | 71.00 | 62.00 | 62.00 | 74.50 | 59.50 | 65.10 | 66.00 | 62.20 | 76.00 | 73.80 | 94.00 |
| Total H. S. ÷ superheating H. S. | 12.40 | ..... | ..... | 7.90 | ..... | 10.50 | 14.70 | 10.97 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 6.63 |
| Equivalent simple cylinder volume, cu. ft. | 33.10 | 26.00 | 28.84 | 28.84 | 24.00 | 24.10 | 20.60 | 24.10 | 20.75 | 19.32 | 20.75 | 19.00 | 20.46 | 23.05 | 19.45 | 17.10 | 17.10 | 16.90 |
| Total H. S. ÷ cylinder volume | 205.00 | 254.00 | 223.00 | 180.00 | 222.00 | 210.00 | 232.00 | 212.00 | 275.00 | 283.00 | 217.00 | 295.00 | 247.00 | 256.00 | 270.00 | 235.00 | 229.00 | 165.00 |
| Superheating H. S. ÷ cylinder volume | 16.40 | ..... | ..... | 22.70 | ..... | 19.90 | 15.74 | 19.30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 24.80 |
| Grate area ÷ cylinder volume | 2.14 | 3.85 | 2.91 | 2.38 | 4.70 | 3 24 | 2.54 | 2.64 | 3.75 | 2.92 | 2.93 | 3.85 | 2.79 | 3.26 | 3.70 | 3.12 | 3.14 | 3.44 |
| Reference in THE AMERICAN ENGINEER | 1909 p. 477 | 1910 p. 207 | 1910 p. 225 | 1909 p. 181 | 1907 p. 341 | 1910 Aug. | 1909 p. 475 | 1910 p. 171 | 1906 p. 371 | 1910 p. 135 | 1908 p. 477 | 1904 p. 237, 262 | 1909 p. 261 | 1910 Aug. | 1909 p. 61 | 1910 p. 225 | 1907 p. 213 | 1910 p. 81 |

* Includes boiler heating surface and feed water heating surface.
† Equipped with Jacobs superheater and feed heater.

** For number and size of tubes see AMERICAN ENGINEER, p. 89, 1910.

# A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

## ARRANGED IN ORDER OF TOTAL WEIGHTS

### FREIGHT AND SWITCHING LOCOMOTIVES

| TYPE | CONSOLIDATION (2-8-0) | | | | | | | | | | | | MIKADO 2-8-2 | | | SWITCHING 0-10-0 | SWITCHING 0-8-0 | SWITCHING 0-6-0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME OF ROAD | N. Y. S. & W. | D. & H. | P. R. R. | W. P. T. | L. S. & M. S. | C. & N. W. | C. & A. | C. G. W. | Wabash | A. T. & S. F. | C.S.N.O. & P. | C. N. O. & T. P. | N. P. | C. M. & St. P. | V. R. R. | L. S. & M. S. | V. R. R. | P.& L.E. |
| Road number or class | 140 | 1,011 | H. S B. | 918 | 5,962 | 1,455 | 438 | ..... | ..... | 1,950 | ..... ..... | 734 | 1,608 | 5202 | 421 | M. | 2 | 253 |
| Builder | Bald. | Amer. | P. R. R. | Amer. | Amer. | Amer. | Amer. | Bald. | Bald. | Bald. | Bald. | Both | Amer. | Shops | Baldwin | Amer. | Amer. | Amer. |
| When built | 1906 | 1906 | 1909 | 1909 | 1906 | 1910 | 1909 | 1909 | 1906 | 1908 | 1907 | 1907 | 1906 | 1909 | 1909 | 1905 | 1909 | 1906 |
| Simple or compound | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Simple |
| Tractive effort, lbs | 54 100 | 49,690 | 42,661 | 46,900 | 45,677 | 47,500 | 39,800 | 46,630 | 42,600 | 44,000 | 43.300 | 44,100 | 46,630 | 46,630 | 50,350 | 55.300 | 45,200 | 44.100 |
| Weight, total, lbs | 260,100 | 246,500 | 238.300 | 236,000 | 232,500 | 232,000 | 228.000 | 222,650 | 214,500 | 212,400 | 207,000 | 203,600 | 261,000 | 260,500 | 254,000 | 270.000 | 182,300 | 178,200 |
| Weight on drivers, lbs | 232,700 | 217,500 | 211,000 | 207,000 | 207,000 | 205,000 | 203,500 | 198,850 | 189,600 | 183.200 | 182 000 | 182.000 | 205 000 | 201,000 | 207,450 | 270,000 | 182,300 | 178,200 |
| Weight on trucks, lbs | 27,400 | 29,000 | 27,300 | 29,000 | 25,500 | ..... | 24,500 | 23,800 | 24.900 | 29,200 | 27,000 | 21,600 | 26,000 | 25,500 | 20,850 | ..... | ..... | ..... |
| Weight on trailer, lbs | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 30,000 | 34,000 | 25,700 | ..... | ..... | ..... |
| Weight, tender loaded, lbs | 161,900 | 152,400 | 158,000 | 154,000 | 149,600 | 150,900 | 165,100 | 144,000 | ..... | 175,200 | 148,000 | 146,400 | 177,800 | 154,000 | 173,000 | ..... | 111,400 | 121,300 |
| Wheel base, driving | 17′ 0″ | 17′ 0″ | 17′ 0½″ | 15′ 9″ | 17′ 6″ | 17′ 6″ | 17′ 9⅛″ | 17′ | 15′ 9″ | 15′ 6″ | 16′ 0″ | 16′ | 16′ 6″ | 16′ 6″ | 15′ 6″ | 19′ 0″ | 14′ | 12′ 0″ |
| Wheel base, engine | 26′ 6″ | 25′11″ | 25″ 9½″ | 25′ | 26′ 5″ | 26′ 5″ | 26′ 9½″ | 25′ 8″ | 24′ 6″ | 24′ 6″ | 24′ 4″ | 24′ 3½″ | 34′ 9″ | 35′ 1″ | 33′ | 19′ 0″ | 14′ | 12′ 0″ |
| Wheel base, engine and tender | 60′10″ | 57′7½″ | 59″ 5⅝″ | 59′11″ | 60′ 9½″ | 60′ 9½″ | 64′ 1 11/16″ | 58′ 6″ | 57′ 10½″ | 58′ 5″ | 56′ 3″ | 56′ 7½″ | 63′ 1″ | 65′ 7½″ | 65′ 10½″ | 54′ 5½″ | 49′ 6⅛″ | 46′ 2½′ |
| Diameter of drivers | 63″ | 57″ | 62″ | 58″ | 63″ | 61″ | 62″ | 63″ | 58″ | 57″ | 57″ | 56″ | 63″ | 63″ | 56″ | 52″ | 51″ | 50″ |
| Cylinders, number | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Cylinders, diameter and stroke | 28″ × 32″ | 23″ × 30″ | 24″ × 28″ | 25″ × 32″ | 23″ × 32″ | 25″ × 32″ | 22″ × 30″ | 24″ × 30″ | 22″ × 30″ | 24″ × 32″ | 22″ × 30″ | 22″ × 30″ | 24″ × 30″ | 24″ × 30″ | 24″ × 32″ | 24″ × 28″ | 22″ × 28″ | 21″ × 30′ |
| Valve gear, type | Wals | Wals. | Wals. | Wals. | Wals. | Wals. | Pilloid | Wals. | Steph. | Wals. | Wals. | Wals. | Wals. | Wals. | Wals. | Wals. | Steph. | Steph. |
| Steam pressure, lbs | 160 | 210 | 205 | 160 | 200 | 170 | 200 | 200 | 200 | 160 | 200 | 200 | 200 | 200 | 180 | 210 | 200 | 200 |
| Boiler, type | Str. | Wooten | Belp. | E. W. T. | Rad. stay | Str. | Str. | Str. | W. T. | Str. | Str. | Str | E. W. T. | E.W.T. | Str. | W. T | Str. | Str. |
| Boiler, smallest diameter | 84″ | 83⅜″ | 76½″ | 80″ | 81⅝″ | 81½″ | 80″ | 80″ | 77″ | 78⅝″ | 78″ | 76¼″ | 75¾″ | 75¾″ | 78¾″ | 80 1/16″ | 74″ | 80″ |
| Boiler, height center | 120″ | 113″ | 117″ | ..... | 118¼″ | 120½″ | ..... | ..... | ..... | 114″ | 115½″ | 114⅜″ | 118″ | 118″ | 112″ | 115″ | 109″ | 108½″ |
| Heating surface, tubes, sq. ft | 3,931 | 3,716 | 3,652 | 3,093 | 3492.18 | 3,499 | 3,175 | 3,514 | 3,053 | 2,773 | 2,939 | 3,051 | 3,192 | 3,332 | 4,277 | 4,422.6 | 2,763 | 2,906 |
| Heating surface, firebox, sq. ft | 198 | 329.5 | 187 | 190 | 213.05 | 214 | 197 | 171 | 192 | 157 | 183 | 175 | 245 † | 282† | 189 | 197 | 177 | 206 |
| Heating surface, total, sq. ft | 4,129 | 4045.5 | 3,839 | 3,283 | 3705.23 | 3,713 | 3,372 | 3,685 | 3,245 | 2,930 | 3,122 | 3,226 | 3,437 | 3,614 | 4,466 | 4,619.6 | 2,940 | 3,112 |
| Heating surface, superheater, sq. ft | 834 | ..... | ..... | 374 | ..... | ..... | ..... | ..... | ..... | 600 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Grate area, sq. ft | 60.2 | 99.85 | 55.13 | 50.5 | 56.5 | 52.7 | 33.6 | 49.5 | 50.4 | 47.4 | 51 | 54 | 43.5 | 48.8 | 51 | 55.4 | 31.5 | 33.3 |
| Firebox, length | 120″ | 126⅛″ | 110½″ | 109″ | 108⅛″ | 108⅛″ | 120⅛″ | 108″ | 108½″ | 95 1/16″ | 108″ | 108″ | 96″ | 107″ | 102″ | 108¼″ | 108″ | 120″ |
| Firebox, width | 72½″ | 114″ | 72″ | 68″ | 75¼″ | 70¾″ | 40½″ | 66″ | 67¼″ | 71¼″ | 68″ | 71¾″ | 65¼″ | 65½″ | 72″ | 73½″ | 42″ | 40″ |
| Fuel, kind | Bit. coal | Anth. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Oil | Bit. coal | Bit. coal | Bit. coal | Bi coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal |
| Tubes, number firetube | 472 | 493 | 465 | 358 | 446 | 443 | 381 | 413 | 360 | 355 | 386 | 403 | 372 | 366 | 374 | 447 | 564 | 430 |
| Tubes, number superheater | ..... | ..... | ..... | 20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Tubes, diameter, firetube | 2″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2¼″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2¼″ | 2″ | 2″ | 2″ |
| Tubes, diameter, superheater | ..... | ..... | ..... | 5½″ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Tubes, length | 16′ | 14′ 6″ | 15′ | 14′ 6″ | 15′ | 15′ 2″ | 16′ | 16′ 4″ | 14′ 6″ | 14′ 11″ | 14′ 6½″ | 14′ 6½″ | 16′ 6″ | 17′ 6″ | 19′ 6″ | 19′ 0″ | 15′ | 13′ 0″ |
| Tender, coal capacity, tons | 15 | 14 | 17.5 | 14 | 12 | 12 | 14 | 12.5 | ..... | 3,300 G | 12 | 12½ | 12 | 14 | 16 | 12 | 10 | 10 |
| Tender, water capacity, gals | 9,000 | 7,800 | 7,000 | 8,000 | 7,500 | 7,500 | 8,500 | 8,000 | 8,000 | 8,500 | 7,500 | 7,500 | 10,000 | 8000 | 9,500 | 8.000 | 5,000 | 7,000 |
| Weight on drivers ÷ tractive effort | 4.3 | 4.3. | 4.95 | 4.41 | 4.5 | 4.30 | 5.10 | 4.28 | 4.44 | 4.17 | 4.2 | 4.13 | 4.38 | 4.31 | 4.10 | 4.86 | 4.03 | 4 04 |
| Weight, total ÷ tractive effort | 4.8 | 4.97 | 5.59 | 5.03 | 5.0 | 4.88 | 5.72 | 4.77 | 5. | 4.75 | 4.76 | 4.61 | 5.6 | 5.80 | 5.05 | 4.86 | 4.03 | 4.04 |
| T. E. × diam. drivers ÷ total H. S | 825. | 700. | 689.00 | 825.00 | 775. | 780.00 | 730.00 | 796.00 | 760. | 855. | 790. | 768. | 855. | 812.80 | 631 00 | 625. | 785.00 | 710. |
| Total heating surface ÷ grate area | 68.50 | 40.5 | 69.64 | 65.00 | 65.8 | 70.40 | 102.00 | 74.3 | 64. | 62. | 61. | 59.80 | 78.8 | 74.00 | 87.50 | 83 | 93.20 | 94. |
| Firebox heat. surf. ÷ total H. S., % | 4.80 | 8.12 | 4.87 | 5.80 | 5.75 | 5.00 | 5.82 | 4.65 | 5.9 | 5.35 | 5.85 | 5.42 | 7.12 | 7.80 | 4.23 | 4.25 | 6.04 | 6.6 |
| Weight on drivers ÷ total heating surface | 56. | 53.5 | 54.96 | 63.00 | 55.8 | 53.90 | 61.00 | 54.00 | 58. | 62.50 | 58.2 | 56.40 | 59.6 | 55.62 | 46.50 | 58.3 | 62.00 | 57.1 |
| Weight, total ÷ total heating surface | 63. | 60.8 | 62.07 | 71.70 | 6.25 | 62.30 | 67.50 | 60.40 | 66. | 72.50 | 66. | 63. | 75.5 | 72.21 | 56 90 | 58.3 | 62.00 | 57.1 |
| Total heat. surf. ÷ superheating heat. surf. | 5. | ..... | ..... | 8.78 | ..... | ..... | ..... | ..... | ..... | 4.90 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Cylinder volume, cu. ft | 22.70 | 14.4 | 14.66 | 18.20 | 15.4 | 18.16 | 13.20 | 15.6 | 13.2 | 16.80 | 13.2 | 13.20 | 15.8 | 15.70 | 16.75 | 14.7 | 12.35 | 12. |
| Total heating surface ÷ cylinder volume | 181. | 280. | 261.89 | 181.00 | 242. | 204.00 | 256.00 | 236.20 | 246. | 174.50 | 236.5 | 244.06 | 218. | 230.19 | 266.00 | 314. | 239.00 | 260. |
| Superheating heat. surf. ÷ cyl. volume | 36.8 | ..... | ..... | 20.6 | ..... | ..... | ..... | ..... | ..... | 35.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Grate area ÷ cylinder volume | 2.65 | 6.92 | 3.76 | 2.78 | 3.66 | 2.90 | 2.55 | 3.18 | 3.8 | 2.82 | 3.87 | 4.10 | 2.76 | 3.10 | 3.05 | 3.78 | 2.55 | 2.77 |
| Reference in THE AMERICAN ENGINEER | 1907 p. 302 | 1907 p. 22 | 1910 p. 69 | 1909 p. 256 | 1906 p. 263 | July 1910 | 1909 p. 270 | 1910 p. 64 | ..... ..... | 1908 p. 112 | 1907 p. 194 | 1908 p. 26 | 1906 p. 392 | 1909 p. 305 | 1909 p. 225 | 1905 p. 330 | 1909 p. 360 | 1906 p. 346 |

† Includes combustion chamber.

# A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

## ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

### PASSENGER LOCOMOTIVES OF THE PACIFIC (4-6-2) AND PRAIRIE (2-6-2) TYPES

| TYPE | PACIFIC (4-6-2) | | | | | | | | | | | | PRAIRIE (2-6-2) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name of road | P. R. R. | N. Y. C. | C. & A. | C.& N.W. | C. & A. | N. P. | G. N.** | C. B. & Q. | A. T. & S. F. | R. F. & P. | N. Y., N.H. & H. | C. B. & Q. | A. T. & S.F. | L.S. & M.S. | C. B. & Q | N. P. | G. N. | Wabash† |
| Road number or class | K 28 | 3565 | 623 | 1,500 | 605 | 2,175 | 1,445 | 2,850 | 1290 | 84 | I1 | S1 | 1800 | 4,724 | R5 | 2,378 | J1 | G1 |
| Builder | Amer. | Amer. | Amer. | Amer. | Bald. | Amer. | Bald. | Bald. | Bald. | Bald. | Both | | Bald. | Amer. | Amer. | Amer. | Bald. | Both |
| When built | 1907 | 1908 | 1909 | 1910 | 1908 | 1906 | 1909 | 1909 | 1908 | 1907 | 1907 | 1906 | 1906 | 1906 | 1906 | 1906 | 1906 | 1907 |
| Simple or compound | Simple | Simple | Simple | Simple | Simple | Comp. | Simple | Simple | Simple | Simple | Simple | Simple | Comp. | Simple | Simple | Simple | Simple | Simple |
| Tractive effort, lbs | 30,700 | 29,200 | 31,475 | 31,900 | 34,500 | 30,340 | 35,300 | 31,100 | 32,600 | 31,100 | 31,560 | 31,100 | 37,800 | 27,850 | 35,060 | 33,300 | 37,560 | 34,556 |
| Weight, total, lbs | 272,500 | 266,000 | 248,000 | 245,000 | 243,200 | 240,000 | 235,750 | 234,900 | 232,750 | 230,800 | 229,500 | 228,000 | 248,200 | 233,000 | 216,000 | 209,500 | 209,000 | 205,900 |
| Weight on drivers, lbs | 183,900 | 171,500 | 149,500 | 151,000 | 146,500 | 157,000 | 152,000 | 160,150 | 140,400 | 143,750 | 142,500 | 150,000 | 174,700 | 165,200 | 152,000 | 152,000 | 151,000 | 150,500 |
| Weight on trucks, lbs | | | | | 47,600 | 53,000 | 39,900 | 37,400 | 54,950 | 46,850 | 46,500 | 42,000 | 31,300 | 26,000 | 25,600 | | 21,000 | 21,900 |
| Weight on trailer, lbs | | | | | 49,100 | 30,000 | 43,850 | 37,350 | 37,400 | 40,200 | 41,000 | 36,000 | 42,200 | 41,800 | 38,400 | | 37,000 | |
| Weight, tender loaded, lbs | 143,800 | 164,000 | 165,120 | 154,000 | 161,800 | 141,350 | 148,200 | 155,100 | 165,200 | 350,000 | 134,000 | 148,200 | 175,000 | 159,900 | 148,200 | 139,500 | 151,000 | 153,000 |
| Wheel base, driving | 13′ 10″ | 14′ | 13′ 9″ | 13′ 6″ | 13′ 9″ | 12′ 0″ | 13′ | 12′ 10″ | 12′ 8″ | 12′ 10″ | 13′ 1″ | 12′ 10″ | 13′ 8″ | 14′ 0″ | 13′ 4½″ | 11′ 0″ | 13′ 0″ | 13′ 4½″ |
| Wheel base, engine | 35′ 2½″ | 36′ 6″ | 34′ 8½″ | 34′ 7″ | 32′ 8″ | 33′ 5″ | 33′ 9″ | 32′ 9″ | 34′ 4½″ | 32′ 8″ | 33′ 5½″ | 32′ 9″ | 33′ 9″ | 34′ 3″ | 30′ 8½″ | 28′ 11″ | 30′ 9″ | 30′ 8½″ |
| Wheel base, engine and tender | 67′ ¾″ | 67′ 11″ | 66′ 4″ | 66′ 10½″ | 65′ 8½″ | 62′ 10″ | 66′ 7½″ | 64′ 3½″ | 65′ 2″ | 61′ 11½″ | 61′ 2″ | 64′ 3½″ | 65′ 0″ | 62′ 5½″ | 62′ 2¾″ | 57′ 3½″ | 63′ 8″ | 61′ 4¼″ |
| Diameter of drivers | 80″ | 79″ | 80″ | 75″ | 73″ | 69″ | 73″ | 74″ | 73″ | 73″ | 73″ | 74″ | 69″ | 79″ | 69″ | 63″ | 69″ | 70″ |
| Cylinders, number | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 |
| Cylinders, diameter | 24″ | 22″ | 23″ | 23″ | 23″ | 16½″ & 27½″ | 26″ | 22″ | 25″ | 22″ | 22″ | 22″ | 17½″ & 29″ | 21½″ | 22″ | 21″ | 22″ | 22″ |
| Cylinders, stroke | 26″ | 28″ | 28″ | 28″ | 28″ | 26″ | 30″ | 28″ | 28″ | 28″ | 28″ | 28″ | 28″ | 28″ | 28″ | 28″ | 30″ | 28″ |
| Valve gear, type | Wals. | Wals. | Pilloid | Wals. | Wals. | Wals. | Wals. | Wals. | | | | Steph. | Wals. | Wals. | Steph. | Steph. | Wals. | Steph. |
| Steam pressure, lbs | 205 | 200 | 200 | 190 | 200 | 220 | 150 | 200 | 160 | 200 | 200 | 200 | 225 | 200 | 210 | 200 | 210 | 210 |
| Boiler, type | Str. | Conical | E. W. T. | E. W. T. | W. T. | E. W. T. | Belp. | W. T. | Str. | Str. | Str. | W. T. | E. W. T. | E. W. T. | W. T. | E. W. T. | Belp. | E. W T |
| Boiler, smallest diameter | 78″ | 72″ | 72″ | 70⅝″ | 72″ | 72½″ | 72″ | 70″ | 72″ | 74″ | 70″ | 70″ | 76″ | 70″ | 70″ | 72⅛″ | 72″ | 70″ |
| Boiler, height center | 119″ | | | 116″ | 113′ | 115″ | 111″ | 109⅞″ | 114¼″ | 112½″ | 110″ | 109¾″ | 115″ | 114″ | 107⅜″ | 115″ | 108″ | 107⅞″ |
| Heating surface, tubes, sq. ft | 4243 | 3981.6 | 3869. | 4130. | 3721. | 2667. | 2920. | 3610. | 3202 | 3917. | 3743. | 3,732. | 3,803. | 3,678. | 3,375. | 2,105. | 3,277. | 3370 |
| Heating surface, firebox, sq. ft | 205 | 228.3 | 202. | 236. | 206. | 241.8 | 213. | 194. | 190 | 190. | 204.4 | 200. | 217. | 227. | 200. | 235. | 210. | 190 |
| Heating surface, total, sq. ft | 4448 | 4209.9 | 4071. | 4366. | 3927. | 2908.8 | 3133. | 3804. | 3392 | 4107. | 3947.4 | 3,932. | 4020. | 3,905. | 3,575. | 2,340. | 3,487. | 3560 |
| Heating surface, superheater, sq. ft | | | | | | | 620. | | | | | | | | | | | |
| Grate area, sq. ft | 61.86 | 56.5 | 49.5 | 53 | 33. | 43.5 | 54.15 | 55. | 49.5 | 49′ 5″ | 53.5 | 54. | 53.8 | 55. | 54. | 43.5 | 53.15 | 54.25 |
| Firebox, length | 111″ | 108⅛″ | 108″ | 108⅛″ | 120⅛″ | 96″ | 126⅛″ | 108⅛″ | 107⅞″ | 108″ | 108⅛″ | 108⅛″ | 107⅛″ | 108⅛″ | 108⅛″ | 96″ | 116″ | 108⅛″ |
| Firebox, width | 80½″ | 75¼″ | 66″ | 70¼″ | 40¼″ | 65¼″ | 66¼″ | 72¼″ | 66″ | 66″ | 71¼″ | 72¼″ | 71⅛″ | 73¼″ | 72¼″ | 65¼″ | 66″ | 72¼″ |
| Fuel, kind | Bit. Coal | Bit. Coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Oil | Bit. Coal | Bit. Coal | Bit. coal. | Bit. Coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal |
| Tubes, number firetube | 343 | 382 | 373 | 396 | 357 | 306 | 160 | 293 | 273 | 318 | 310 | 303 | 342 | 322 | 303 | 306 | 301 | 303 |
| Tubes, number superheater | | | | | | | 32 | | | | | | | | | | | |
| Tubes, diameter, firetube | 2¼″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2½″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¼″ | 2¾″ | 2¼″ | 2¼″ | 2″ | 2¼″ | 2¼″ |
| Tubes, diameter superheater | | | | | | | 5½″ | | | | | | | | | | | |
| Tubes, length | 21′ | 20′ | 20′ | 20′ | 20′ | 16′ 9″ | 21′ | 21′ | 20′ | 21′ | 20′ 6″ | 21′ 0″ | 18′ 10⅛″ | 19′ 6″ | 19′ 0″ | 13′ 3″ | 18′ 6″ | 19′ |
| Tender, coal capacity, tons | 11 | 14 | 14 | 13 | 12½ | 12 | 13 | 13 | 33,009 | 12 | 14 | 13 | 14 | 15 | 13 | 12 | 13 | 15 |
| Tender, water capacity, gals | 7000 | 8000 | 8500 | 7,500 | 8,250 | 7,000 | 8,000 | 8,200 | 8,500 | 6,000 | 6,000 | 8,000 | 9,000 | 8,000 | 8,000 | 7,000 | 8,000 | 7,700 |
| Weight on drivers ÷ tractive effort | 6.00 | 5.84 | 4.74 | 4.73 | 4.26 | 5.2 | 4.31 | 5.17 | 4.33 | 4.62 | 4.5 | 4.8 | 4.6 | 4.4 | 4.3 | 4.6 | 4. | 4.35 |
| Weight, total ÷ tractive effort | 8.85 | 9.11 | 7.90 | 7.68 | 7.05 | 7.9 | 6.68 | 7.55 | 7.12 | 7.65 | 7.25 | 7.3 | 6.6 | 8.3 | 6.2 | 6.3 | 5.6 | 5.95 |
| T. E. × diameter drivers ÷ total H S | 550.00 | 550.00 | 618.00 | 548.00 | 640.00 | 720. | 822.00 | 605.00 | 700.00 | 560.00 | 585.00 | 585. | 650.00 | 565. | 677. | 900. | 746. | 680.00 |
| Total heating surface ÷ grate area | 72.00 | 74.50 | 82.30 | 82.40 | 119. | 67. | 57.85 | 69.20 | 68.50 | 82.90 | 73.50 | 71.3 | 74. | 71. | 64.8 | 53.8 | 65. | 65.70 |
| Firebox heat. surf. ÷ total H.S. % | 4.62 | 5.35 | 4.98 | 4.79 | 5.24 | 8.3 | 6.80 | 5.10 | 5.60 | 4.64 | 5.20 | 4.85 | 5.4 | 5.8 | 5.34 | 10.1 | 6.0 | 5.32 |
| Weight on drivers ÷ total heat. surf | 41.50 | 40.70 | 36.60 | 34.80 | 37.30 | 53.8 | 48.51 | 42.40 | 41.50 | 34.90 | 36.20 | 38. | 43.5 | 42. | 42.5 | 65. | 43.5 | 42.20 |
| Weight total ÷ total heating surface | 61.20 | 63.10 | 61.00 | 56.20 | 62.00 | 82.5 | 75.24 | 61.30 | 68.50 | 56.10 | 58.20 | 58. | 62. | 61. | 60.7 | 89.5 | 60. | 58.00 |
| Total H.S. ÷ superheating heat. surf | | | | | | | 5.05 | | | | | | | | | | | |
| Cylinder volume, cubic feet | 13.60 | 12.32 | 13.50 | 13.28 | 13.00 | 9.9* | 18.50 | 12.30 | 16.00 | 12.30 | 12.30 | 12.3 | 12.1* | 11.7 | 12.3 | 11.2 | 13.2 | 12.32 |
| Total heating surface ÷ cyl. volume | 326.00 | 341.00 | 302.00 | 328.00 | 290.00 | 294. | 169.34 | 310.00 | 212.00 | 334.00 | 321.00 | 318. | 334. | 335. | 290. | 209. | 265. | 290.00 |
| Superheating heating surf. ÷ cyl. vol | | | | | | | 3.40 | | | | | | | | | | | |
| Grate area ÷ cylinder volume | 4.55 | 4.58 | 3.67 | 3.99 | 2.44 | 4.3 | 2.92 | 4.48 | 3.10 | 4.03 | 4.20 | 4.39 | 4.43 | 4.68 | 4.46 | 3.89 | 4.03 | 4.41 |
| Reference in THE AMERICAN ENGINEER | 1907 p. 267 | 1908 p. 164 | | This Issue | 1908 p. 399 | 1906 p. 411 | 1909 p. 413 | 1909 p. 376 | 1908 p. 112 | 1907 p. 407 | 1907 p. 431 | 1906 p. 300 | 1906 p. 435 | 1906 p. 204 | 1906 p. 300 | 1906 p. 392 | 1906 p.365 | 1908 p. 31 |

* Equivalent simple cylinders.
** With superheater.
† Designed for fast freight service.

* Equivalent simple cylinders.
** With superheater.
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# A TABULAR COMPARISON OF NOTABLE EXAMPLES OF RECENT LOCOMOTIVES

## ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS

### PASSENGER LOCOMOTIVES OF TYPES OTHER THAN THE PACIFIC AND PRAIRIE

| TYPE | ATLANTIC (1-4-2) | | | | | | | | | TEN WHEEL (4-6-0) | | | | | | | AMERICAN (4-4-0) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name of road | U. P. | Erie | C. M. & St. P. | P. R. R. | N. Y. N. H. & H. | N. P. | C. B. & Q. | Har. Lines | C. R. I. & P. | B. & A. | S. P. | D. L. & W. | C. G. W. | N. Y. C. | N. C. & St. L. | C. & N. W | C. R. R. of N. J. | D. L. & W. |
| Road number or class | 21 | 537 | 951 | 2,760 | F1 | 603 | P3 | A-81 | 1,019 | 1,916 | 2,317 | 1,012 | 500 | 2,099 | 284 | | 852 | 955 |
| Builder | Baldwin | Amer. | Bald. | Amer. | Amer. | Bald. | Bald. | Bald. | Amer. | Amer. | Bald. | Amer. | Bald. | Amer. | Bald. | Amer. | Amer. | Amer. |
| When built | 1906 | 1905 | 1907 | 1905 | 1907 | 1909 | 1904 | 1905 | 1905 | 1908 | 1907 | 1905 | 1909 | 1905 | 1908 | 1907 | 1905 | 1905 |
| Simple or compound | Comp. | Comp. | Comp. | Comp. | Simple | Simple | Comp. | Simple | Simple | Simple | Simple | Simple | Simple | Simple | Bal.comp | Simple | Simple | Simple |
| Tractive effort, lbs | 24,281 | 23,860 | 22,200 | 23,300 | 24,670 | 24,760 | 21,400 | 23,560 | 24,700 | 31,000 | 36,570 | 35,100 | 33,060 | 31,000 | 29,200 | 30,900 | 23,120 | 23,710 |
| Weight, total, lbs | 209,000 | 206,000 | 204,119 | 200,500 | 200,000 | 197,050 | 196,600 | 196,000 | 191,300 | 208,000 | 203,300 | 201,000 | 198,050 | 194,500 | 181,400 | 179,500 | 161,300 | 151,200 |
| Weight on drivers, lbs | 110,000 | 115,000 | 105,966 | 117,200 | 105,500 | 100,800 | 101,200 | 105,000 | 107,100 | 158,000 | 160,000 | 154,000 | 144,950 | 148,000 | 134,000 | 135,500 | 111,300 | 100,000 |
| Weight on trucks, lbs | 53,000 | 52,000 | 52,353 | 52,500 | 48,000 | 51,950 | 54,200 | 45,000 | 42,400 | | | 47,000 | 53,100 | 46,500 | 47,400 | 44,000 | 50,000 | 51,200 |
| Weight on trailer, lbs | 46,000 | 39,000 | 45,800 | 30,000 | 46,500 | 44,300 | 41,200 | 46,000 | 40,800 | 155,800 | 43,300 | | | | | | | |
| Weight, tender loaded, lbs | 162,200 | 162,800 | 130,000 | 132,500 | 134,000 | 122,950 | 120,400 | 162,200 | 144,000 | | 141,366 | 120,000 | 144,000 | 143,500 | 118,000 | 139,500 | 122,200 | 110,000 |
| Wheel base, driving | 7′ 0″ | 7′ 0″ | 7′ 6″ | 7′ 5″ | 7′ 3″ | 6′ 10″ | 7′ 3″ | 7′ 0″ | 7′ 0″ | 15′ 10″ | 13′ 10″ | 14′ 4″ | 15′ 3″ | 15′ 10″ | 12′ 0″ | 14′ 10″ | 8′ 3″ | 8′ 6″ |
| Wheel base, engine | 27′ 10″ | 28′ 0″ | 32′ 2″ | 31′ 11″ | 28′ 2″ | 27′ 10″ | 30′ 2″ | 27′ 7″ | 27′ 5½″ | 26′ 10½″ | 25′ 10″ | 25′ 6″ | 27′ 1″ | 26′ 10½′ | 26′ 0″ | 25′ 10″ | 23′ 1½″ | 24′ 5″ |
| Wheel base, engine and tender | 58′ 5″ | 60′ 9″ | 66′ 9″ | 61′ 4″ | 56′ 1″ | 57′ 3″ | 57′ 6¾″ | 58′ 2″ | 57′ 2″ | 59′ 3″ | 58′ ¼″ | 54′ ¼″ | 57′ 9½″ | 59′ 2″ | 55′ 2″ | 57′ 9″ | 49′ 2″ | 51′ 3/4″ |
| Diameter of drivers | 81″ | 78″ | 85″ | 80″ | 79″ | 73″ | 78″ | 81″ | 73″ | 69″ | 63″ | 69″ | 73″ | 69″ | 66″ | 63″ | 69″ | 69″ |
| Cylinders, number | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| Cylinders, diameter | 16″ & 27″ | 15½ & 26″ | 15″ & 25″ | 16″ & 27′ | 21″ | 21″ | 15″ & 25″ | 20″ | 21″ | 22″ | 22″ | 21½″ | 26″ | 22″ | 16″ & 27″ | 21″ | 19″ | 20″ |
| Cylinders, stroke | 28″ | 26″ | 28″ | 26″ | 26″ | 26″ | 26″ | 28″ | 26″ | 26″ | 28″ | 26″ | 28″ | 26″ | 26″ | 26″ | 26″ | 26″ |
| Valve gear, type | Wals. | Steph. | | Steph. | | Wals. | Steph. | Steph. | Steph. | | | Steph | Wals. | Steph. | Wals. | Wals. | Steph. | Steph |
| Steam pressure, lbs | 200 | 220 | 220 | 205 | 200 | 185 | 210 | 200 | 185 | 200 | 200 | 215 | 150 | 200 | 210 | 200 | 200 | 185 |
| Boiler, type | Str. | E. W. T. | W. T. | Belp. | E. W. T. | Str. | E. W. T. | Str. | Str. | E. W. T. | W. T. | Str. | Str. | W. T. | W. T | E. W. T. | W. T. | Str. |
| Boiler, smallest diameter | 70″ | 70¾″ | 66″ | 65⅜″ | 68″ | 72⅛″ | 64″ | 70″ | 72″ | 72½″ | 72″ | 74⅝″ | 70″ | 70⅜″ | 64″ | 66⅜″ | 62¼″ | 61⅛″ |
| Boiler, height center | 113″ | 111⅜″ | 114″ | 109″ | 110″ | | 108⅛″ | 113″ | 108″ | 115″ | 102″ | 116½″ | | 115″ | 107″ | | 113″ | |
| Heating surface, tubes, sq. ft | 2475. | 3453.6 | 3008. | 2680.2 | 3041. | 2112. | 3050.5 | 2475. | 2227.6 | 3104.5 | 2788. | 3156.3 | 2,206 | 3124.7 | 2550 | 2808.4 | 1838.1 | 1947.9 |
| Heating surface, firebox, sq. ft | 180. | 181.1 | 168. | 181.4 | 204.4 | 173. | 155.5 | 174. | 161.8 | 203.3 | 206. | 221.7 | 149 | 202.7 | 185 | 150.8 | 167.6 | 190.8 |
| Heating surface, total, sq. ft | 2655. | 3634.7 | 3194. | 2861.6 | 3245.4 | 2285. | 3206. | 2649. | 2389.4 | 3307.8 | 2994. | 3378. | 2,355 | 3326.7 | 2735 | 2959.2 | 2005.7 | 2138.7 |
| Heating surface, superheater, sq. ft | | | | | | 480. | | | 338. | | | | 460 | | | | | |
| Grate area, sq. ft | 49.5 | 56.5 | 45. | 55.5 | 53 5 | 43.5 | 44.1 | 49.5 | 44.8 | 54.9 | 32.1 | 94.8 | 49.5 | 54.93 | 34.8 | 46.27 | 81.6 | 87.54 |
| Firebox, length | 108″ | 108⅛″ | 107″ | 111″ | 108⅛″ | 96″ | 96⅛″ | 108″ | 96″ | 105⅛″ | 124″ | 126⅛″ | 108″ | 108⅛″ | 120″ | 102⅛″ | 122⅛″ | 126⅜″ |
| Firebox, width | 66″ | 75⅛″ | 60⅛″ | 72″ | 71⅞″ | 65¼″ | 66¾″ | 66″ | 67⅞″ | 75¼″ | 37¼″ | 108¼″ | 66½″ | 75¼″ | 41⅞″ | 65¼″ | 96¾″ | 100″ |
| Fuel, kind | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Oil | Anth. coal | Bit. coal | Bit. coal | Bit. coal | Bit. coal | Anth. coal | Anth. coal |
| Tubes, number firetube | 297 | 388 | 268 | 315 | 347 | 196 | 264 | 297 | 173 | 400 | 355 | 398 | 203 | 400 | 256 | 337 | 280 | 280 |
| Tubes, number superheater | | | | | | 22 | | | 54 | | | | 24 | | | | | |
| Tubes, diameter, firetube | 2″ | 2″ | 2¼″ | 2″ | 2″ | 2″ | 2¼″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2″ | 2¼″ | 2″ | 2″ | 2″ |
| Tubes, diameter, superheater | | | | | | 5½″ | | | 3½″ | | | | 5″ | | | | | |
| Tubes, length | 16′ 0″ | 17′ 0″ | 19′ | 16′ 3″ | 16′ 10″ | 16′ | 19′ 0″ | 16′ 0″ | 16′ 0″ | 14′ 11″ | 15″ | 15′ 3″ | 16′ | 14′ 11″ | 17′ | 16′ 0″ | 12′ 6″ | 13′ 4¼″ |
| Tender, coal capacity, tons | 10 | 16 | 10 | 12½ | 14 | 9 | 12 | 10 | 12 | 12 | 2,940 | 10 | 12½ | 12 | 10.5 | 10 | 12 | 10 |
| Tender, water capacity, gals | 9,000 | 8,500 | 7,000 | 5,500 | 6,000 | 6,000 | 6,000 | 9,000 | 7,000 | 8,000 | 7,000 | 6,000 | 8,000 | 7,000 | 5,500 | 7,500 | 5,000 | 5,000 |
| Weight on drivers ÷ tractive effort | 4.53 | 4.82 | 4.75 | 5. | 4.27 | 4.05 | 4.7 | 4.48 | 4.2 | 5.10 | 4.37 | 4.38 | 4.38 | 4.77 | 4.58 | 4.38 | 4.8 | 4.22 |
| Weight total ÷ tractive effort | 8.6 | 8.63 | 9.20 | 8.6 | 8.10 | 7.95 | 9.2 | 8.35 | 7.8 | 6.70 | 5.57 | 5.72 | 5.99 | 6.27 | 6.27 | 5.80 | 6.95 | 6.4 |
| T. E. × diam. drivers ÷ total H. S. | 740. | 513. | 610. | 650. | 600. | 790. | 518.8 | 717. | 754. | 647. | 770. | 717. | 1024. | 647. | 705. | 655. | 800. | 765. |
| Total heat. surf. ÷ grate area | 53.8 | 64.3 | 70.50 | 51.6 | 60.50 | 52.30 | 73. | 53.6 | 53.3 | 60.20 | 93. | 35.6 | 47.50 | 60.5 | 78.50 | 64. | 24.7 | 24.4 |
| Firebox heat. surf. ÷ total H. S. % | 6.8 | 5. | 5.30 | 9.37 | 6.30 | 7.60 | 4.85 | 6.6 | 6.75 | 6.15 | 6.90 | 6.6 | 6.30 | 6.1 | 6.80 | 5.10 | 8.4 | 8.9 |
| Wgt. on drivers ÷ total heat. surf | 41.5 | 31.7 | 33.10 | 41. | 32.60 | 43 80 | 31.5 | 39.6 | 44.8 | 51. | 53.40 | 45.6 | 61.50 | 44.5 | 49.00 | 45.75 | 55.3 | 46.8 |
| Wgt. total ÷ total heat. surf | 78.9 | 56.8 | 64. | 70. | 61.80 | 79.50 | 61.3 | 74. | 80. | 67. | 68. | 59.8 | 81.10 | 58.7 | 67.00 | 60.50 | 80.5 | 71. |
| Total H. S. ÷ superheating heat. surf. | | | | | | 4.76 | | | 7.08 | | | | 5.10 | | | | | |
| Cylinder volume, cu. ft | 10.2† | 8.93† | 9.† | 10.2† | 10.40 | 10.40 | 8.3† | 10.2 | 10.4 | 11.40 | 12.30 | 10.9 | 17.20 | 11.4 | 10.20 | 10.4 | 8.6 | 9.5 |
| Total heat. surf. ÷ cyl. vol | 262. | 408. | 355. | 280. | 311. | 219.00 | 387. | 260.7 | 230. | 288. | 243. | 311. | 136.90 | 292. | 268.00 | 287. | 233. | 224. |
| Sup. heat. surf. ÷ cyl. vol | | | | | | 46.20 | | | 32.5 | | | | 26.70 | | | | 9.5 | 9.2 |
| Grate area ÷ cyl. vol | 4.83 | 6.27 | 5. | 5.42 | 5.16 | 4.19 | 5.3 | 4.85 | 4.3 | 4.8 | 2.61 | 8.68 | 2.88 | 4.8 | 3.40 | 4.45 | | |
| Reference in THE AMERICAN ENGINEER | 1906 p. 308 | 1905 p. 287 | 1908 p. 37 | 1906 p. 73 | 1907 p. 471 | 1909 p.195 | 1904 p. 212 | 1905 p. 154 | 1905 p. 329 | 1910 p. 64 | 1907 p. 481 | 1905 p. 407 | 1910 p. 64 | 1906 p. 59 | 1909 p. 52 | 1907 p. 247 | | |

† Equivalent Simple Cylinders.